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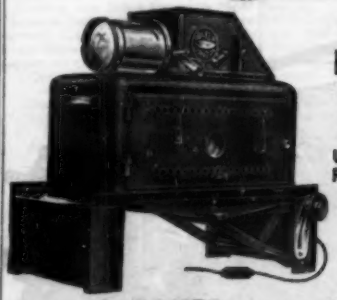

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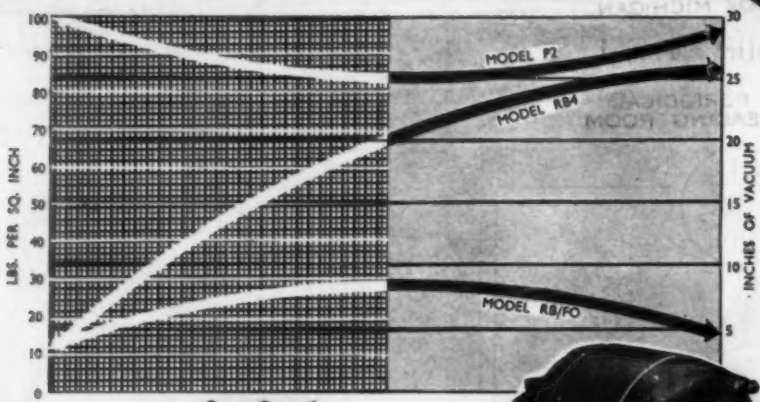

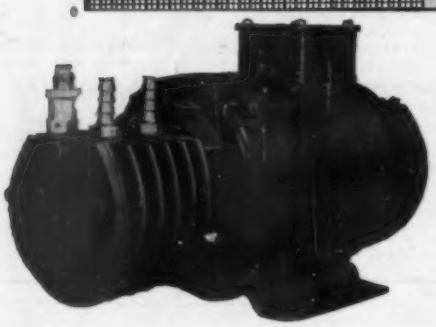

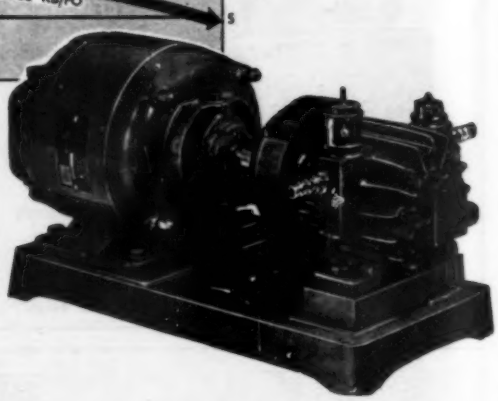

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SCIENCE AND THE MACHINERY OF GOVERNMENT

A RECENT study of democracy by the warden of Nuffield College, Mr. Alexander Loveday, published under the title "The Only Way"*, well illustrates the point that the proper concern of the scientific man or other professional worker for the conditions under which he can most effectively pursue his occupation and maintain the highest standards and traditions makes it impossible for him, collectively or individually, to be indifferent to the political conditions or climate in which he works. The issues involved may be such as to affect directly the maintenance of professional standards of conduct or the advancement of science, and there would be dereliction of public duty if those concerned, either through their professional associations or as individuals, did not explain the situation to the public and suggest remedies.

Clearly there will always be room for differences of opinion as to where to make a stand. One reflexion suggested by Mr. Loveday's study of the dangers affecting democracy is that those men of science who have been seriously concerned with the effect on their science of the political conditions under which they pursue their work have substantial justification for their fears about possible adverse effects to-day. Conditions detrimental to political freedom, including freedom of communication and movement generally, are rarely anything but detrimental to the atmosphere in which science and other creative activities flourish.

A second reflexion suggested by this same book is that the steady erosion during the past few decades of the ideals and standards of democracy has reached a point when the preservation of science itself requires men of science to join in resisting that process. To Mr. Loveday, democracy is something more than a mode of government; it implies a way of life, a body of doctrine which determines that way, and the faith which inspires that doctrine. He is more concerned with democratic societies than governments, and with social values and conceptions of welfare than with constitutions; and while he admits that in no society is there a rigid order of values, he points out that many of the most important democratic ideals find their clearest expression in the rules of conduct which constitute our ethical system. Four principles, he suggests, have guided democracies in their attempt to find a solution to the problems of individual freedom and self-realization: the individual is himself the best judge and the best exponent of his own capacities; the criteria for expression and development are seen in the degree of internal harmony finally achieved; likewise, actions which disturb social harmony should be avoided, and those which promote social harmony, or are required to protect society, should be carried out.

These second and third principles are intermeshed, because man is a social being. Moreover, Mr. Loveday

* The Only Way. By A. Loveday. Pp. xvi+221. (London: W. Hodge and Co., Ltd., 1950.) 12s. 6d.

maintains that man is more than a material object; materialism, he believes, is the antithesis of democracy, and Mr. Loveday's fourth principle is that, to the extent that science can assist man to determine his individual and collective capacities, it should be used and its findings put at the disposal of the individual to aid him in making his own choice. It will be apparent already that Mr. Loveday's views as to the contribution of science, and particularly the functions of planning, are restrained; but the limitations are not so much inherent in science or in the technique of planning as in the capacity of those by whom they are used or the individuals for whose benefit they are applied.

The most arresting feature of this book is indeed its exposition of the faults of social and economic planning in general, and its demonstration that the difficulties arise when the necessary understanding and co-operation are not forthcoming in the community. It is then, when the element of compulsion comes in, that democratic ideals and values are endangered, because without public response and understanding it is impossible for the objectives of the planners to be secured at any stage short of a totalitarian regime, which is the negation of democracy. The danger to democracy arises, in fact, not from the technique of planning as such, but when groups and individuals in the community ignore their duties and responsibilities to that community, and fail to exercise that self-control and discipline which a democracy implicitly demands. If the requisite effort is not forthcoming from the community, planning at once launches us on the slippery road to full totalitarianism.

Prof. R. M. MacIver wrote recently in "The Ramparts We Guard"*: "The assumption of democracy is that the sense of the public interest will move the majority of the public and that it will on the whole over-ride the encroachments and aggressions of particular private interests. If this assumption should prove false, democracy must, in the long run, break down. Democracy cannot long co-exist with group anarchy." Mr. Loveday puts the same truth in other words, which point even more clearly to dangers inherent in certain events since both books were written: "The gravest threat to individual liberty, however, arises not when there is a failure by some group or even by the whole community to perform some social function expected of it, but when any group causes inflation by endeavouring to secure for itself too great a share of the national resources".

Mr. Loveday's book is more than a realistic discussion of the nature of freedom and of the way in which physical rights are the prerequisite of all others. It gives also an objective review of post-war policy in Great Britain which shows clearly the extent to which democratic ideals and traditions are already endangered by forms of economic control which are the very antithesis of the social system and the ethic for which democracy stands. The antithesis arises, indeed, not from control as such but from the extension of control to a point at which the degree imposed threatens the scope for personal development and the internal harmony of the individual, or at which some other objective than the attainment of that development and harmony is accepted as the purpose of government.

The central thesis of this book is that the harmony of the democratic society in which we live depends on the respect paid by individual citizens to the ethical principles on which it is based. That those principles have been disregarded on occasions, both in government policy and in the actions of certain groups in the community, is a matter of wide concern. Mr. Loveday does not provide facile answers; but some of the major issues are clearly displayed, and indications are given of ways in which the dangers may be diminished. In some of these, men of science may perhaps contribute directly. They may be able to help individually and professionally in the transmission of the democratic ethic and especially of the principle of toleration. They could, at least by example, combat the tendency to excessive submission to authority, and help to encourage the growth of alert and responsible public opinion, prompt to detect and expose abuse of power. By training and tradition they are qualified to set an example of the moderation in demands and in behaviour which the preservation of liberty requires.

Mr. Loveday's study is concerned essentially with the social aspects of a democratic society and the way in which they impinge on the conduct and ideals of its constituent groups; recent pamphlets on the nationalized industries now being issued by the Acton Society Trust (see *Nature*, April 14, p. 595) show how the structure of government is also involved. Democracy is threatened not only by the immoderate demands of constituent groups who ignore or repudiate the values and ideals on which it is based; it can also be endangered by forms of organization which are ill-adapted to the purposes they are intended to serve.

That much is brought out particularly in the Acton pamphlets on accountability to Parliament and on problems of promotion policy, both of which insist on the need for impartial but searching examination of the problems. Insistence on the need for such scientific and impartial investigation is one of the features common not only to Mr. Loveday's book and these pamphlets but also to the study of "British Government since 1918"*, instigated by the Institute of Public Administration. Mr. Loveday looks to the universities, for example, to play a leading part in the analysis and interpretation of the principles of democracy, and particularly in the deeper study and wider teaching of democratic values which are necessary to avert the present threat. The consequent public understanding is as important as moderation both in demands and in behaviour if democracy is to survive. In "British Government since 1918", the same note is struck by several contributors. Prof. W. J. M. Mackenzie's review of

* "The Ramparts We Guard." By Prof. R. M. MacIver. (New York and London: Macmillan and Co., Ltd., 1950.) 22s. 6d.

* British Government since 1918. By Sir Gilbert Campion, D. N. Chester, Prof. W. J. M. Mackenzie, Prof. William A. Robson, Sir Arthur Street and J. H. Warren. Pp. 232. (London: George Allen and Unwin, Ltd., 1950.) 16s. net.

the structure of central administration, which includes a penetrating criticism of the Haldane Report on the machinery of government bearing closely on the issues raised in the recent re-allocation of responsibilities between the Ministry of Health and the Ministry of Local Government and Planning, stresses in this very connexion that the first essential for reform is public and professional interest and understanding; until these are stirred, it is useless to think that anything substantial can be achieved by reorganization at the centre. Similarly, in his survey of administrative law in England, 1919–48—much the largest study in the book—Prof. W. A. Robson not only brings out the implications for personal freedom and justice of some of the developments, such as the increasing practice of delegating legislative powers to the executive, but also the importance both of Parliament taking a serious and continuing interest in the subject and of the quality and quantity of public law teaching and research in the universities.

There is in truth some overlapping and repetition in these studies, and the treatment of the themes is not always in proportion. Nevertheless, although the book scarcely contains, as Sir John Anderson suggests, all the information which a student or general reader may require on the subject, it indicates both the need for impartial study of the whole structure of government and also very precisely some of the weaknesses of the present system and the points at which constructive thought is required.

One thing that emerges is the extent to which the real problems are independent of party politics, but are likely to require the combined effort of open minds of all parties to work out effective solutions and secure their adoption. To the man of science, Prof. Mackenzie's paper is one of the most interesting, not simply because it reminds us that academic freedom at present depends in part on inefficiency in the machinery of government, or because it discusses the organization of research in the light of the Haldane Committee's advocacy of a central department of research, but rather for its insistence that the problem is a practical one and not purely theoretical. In fact, Prof. Mackenzie's conclusion is all against reorganization beyond the very minimum, and he believes that the less dislocation the Departments of State suffer at present the better.

So far as reform is concerned, the major issue raised in the book is that of local government. Both Prof. Robson and Mr. J. H. Warren firmly challenge the Government's abolition of the Local Government Boundary Commission, and their essays lend strong support to Sir Malcolm Trustram Eve's plea, in a lecture given in the University of London on February 6, for reform of the structure of local government. Both make it evident that reform alone can arrest and reverse the decline in a political institution which was never more needed than to-day to preserve the vitality of democracy, and to give individuals a means of expression and interest to offset the tendencies which make so much of the organization of government not merely complex and immense but also remote and impersonal.

It is true that, as Mr. Warren points out, political principle must always be conditioned by administrative considerations, and that the particular sphere to be assigned to local self-government is not a question which can be determined wholly by considerations of democratic responsibility, viewed as capable of development by ties of neighbourhood and the activity of local communities, or even by the consideration that local self-government is an educative process and invaluable to democracy on that account alone. To admit that some regard must be had to administrative consideration in assigning local government functions is not to allow, however, that such considerations should be the sole or even the decisive factor. Moreover, as Prof. Mackenzie remarks, while the Haldane principle, of allotting functions by services to be rendered rather than by clients to be served, is the most economical way in which to use a limited staff of experts, it is not necessarily the most economical for the public.

The Haldane principle was formulated in respect of government departments, but there and in local government it may sometimes be wise and indeed necessary to break it on other considerations. Certainly, the recent changes in ministerial responsibilities should be considered from other points of view. Even if it is reasonable in theory for the new Ministry of Local Government and Planning to take in the whole range of public housing, planning and the control of the use of land, it does not follow that it is reasonable practice. The Ministry of Town and Country Planning has hitherto given little evidence that it has the standing required to enable it to adjudicate with authority between the demands of defence, industry, agriculture and amenity, and to provide a national plan rather than a series of local truces, nor does the new Ministry possess any local government tradition. There are likewise reasons for holding that the functions of the Ministry of Health have now become too restricted, and that its responsibilities should extend to those environmental services like water and sewerage, sewage disposal, street cleansing and similar matters, in which public health is the dominant consideration.

There is plainly room for some clear thinking on points such as these, and the basis should not be adherence rigidly to some theoretical principle of distribution of functions, but consideration of the practical issues and, above all, of the public to be served. It is because of this that the matter is one which deserves attention, not simply by the administrative expert but also by professional men, many of whom have to man the services concerned, and by the ordinary citizen. Whether or not housing would better have been placed with the Ministry of Works, it is vitally important that the new Ministry of Local Government and Planning should be as neutral as possible as well as authoritative in co-ordinating the claims on resources put forward by various government departments. Success in that field, however, will never compensate for failure to deal as a matter of urgency with the question of local government reform. There the recommendations of the Boundary Commission, based on an exhaustive survey, have

narrowed the range of disinterested argument to limits within which a broadly satisfactory solution could be reached if the Government would give a lead. Nor is it a matter which is a party issue. It will augur ill for the future of democracy if, even in the present circumstances, the Government refuses the opportunity of effecting a reform which could bring new life and interest just where it is most needed to give real meaning to democracy and freedom. Once local government and local democracy become ineffective, other groups, such as the professional associations, are unlikely to find that they can for long provide the means for the individual to contribute effectively to the great task of government, or that the atmosphere of freedom in which they thrive and do their most creative work will long survive.

PHYSIOLOGICAL FOUNDATIONS OF MYCOLOGY

Physiology of Fungi

By Dr. Lilian E. Hawker. Pp. xvi+360+5 plates. (London: University of London Press, Ltd., 1950.) 21*s.* net.

WITHIN every problem of fungal ecology is embedded a problem of fungal physiology. Mycologists have become diverse and specialized in their particular interests; but none can afford to neglect the unifying discipline of physiology. It seems all the more remarkable that, until recently, no text-book of general fungal physiology was available, nor had anyone produced even a comprehensive modern review article to fill this gap. In 1947, F. A. Wolf and F. T. Wolf made a courageous attempt to supply this need in the second volume of their text-book "The Fungi". Ranging widely over the fields of fungal physiology, biochemistry and ecology, these authors were unable to do full justice to the great volume of work published on fungal physiology alone. Jackson W. Foster's "Chemical Activities of Fungi", published in 1949, is exceedingly comprehensive within the restricted scope defined by its title; but many aspects of fungal physiology have been deliberately excluded from consideration by this author. It has thus been left to Dr. L. E. Hawker to produce the first truly comprehensive work on the physiology of fungi, and she has rendered thereby a signal service to all mycologists.

This book owes not a little to the environment that has nurtured it, the Department of Botany at the Imperial College of Science and Technology, London, as Dr. Hawker has indeed acknowledged in the tribute she pays to Prof. William Brown in her preface. As a fungal physiologist and pioneer investigator of the physiology of parasitism, with which his name will always be specially associated, William Brown occupies a unique position, in the acknowledgment of which Dr. Hawker has placed in her debt a host of Prof. Brown's former research students, for many of whom this association has been deeply significant for their subsequent output. It will always be regretted that Prof. Brown did not find time to write such a book himself; but let it be said at once that upon none of his former associates could the cloak of Elijah have descended more fittingly than upon Dr. Hawker, who is well known for her own distinguished researches on fungal physiology, particularly with respect to growth factors and carbohydrate metabolism.

Although biochemists have become increasingly interested in the physiology of fungi and other micro-organisms, as much as ever yet awaits investigation in the field of gross fungal physiology, which still remains the proper sphere of the mycologist as such. As Prof. Brown remarks in his foreword to this book: "In the last resort, the greatest scientific interest concerned lies in the functioning of the organism as a whole". This book presents, in fact, a study of the whole fungus in relation to the whole of its environment, and it comprises a body of knowledge which is essential for any mycologist who has to manage fungi as living organisms. The comprehensive scope of this work is indicated by the chapter headings: following upon the introduction come chapters on growth and variation, nutrition, respiration and fermentation, effect of nutrition on sporulation, other environmental factors affecting growth and reproduction, survival and germination of spores, and interaction, including parasitism, with other organisms.

Such criticisms as can be made relate chiefly to errors of omission, which may be ascribed in part to a prolonged gestation in press. Aeration of culture solutions and the shake culture technique, which have been exhaustively discussed by Foster, are barely mentioned here. It seems unduly conservative to dismiss these new techniques, together with the perfusion technique, as not "practicable on a large scale in the average laboratory" (p. 21). The replacement culture method for dissimilation studies is not mentioned.

Apart from such relatively minor gaps, this book has been admirably planned and executed, and is singularly free from typographical and trivial errors. It is not easy to produce a standard work of reference; it is still more difficult to reduce such a mass of data as Dr. Hawker has had to handle to a text that can be read straight through without effort. This second objective, unperceived, rejected or abandoned in despair by more prolific writers, has also been achieved by Dr. Hawker, and this is not the least part of her success in the production of a very useful and timely book.

S. D. Garrett

SPACE–TIME STRUCTURE

Space–Time Structure

By Erwin Schrödinger. Pp. viii+119. (Cambridge: At the University Press, 1950.) 12*s.* 6*d.* net.

SCHRÖDINGER shares with Einstein the belief that there must be a natural generalization of the relativistic theory of gravitation which could serve as a secure base for dealing with all other natural phenomena: electro-magnetism, meson fields and their interactions. Einstein himself has given a short account of his ideas in a little book, "The Meaning of Relativity", which I have reviewed in *Nature* (166, 751; 1950). In fact, the two books by Einstein and Schrödinger have a common background of conviction and method; their aim is the same. But otherwise they differ thoroughly. Einstein's book discusses the idea of a unified theory only in a brief and condensed appendix, while the main text (a revised version of his Stafford Little Lectures of 1921, published 1922) is a rather elementary account of special and general relativity which can be recom-

mended to students as an introduction to the subject. Schrödinger's new book is an attempt to prepare the reader right from the beginning for the generalized unitary theory. This is achieved by an extremely careful, and at the same time most elegant, development of tensor calculus in three stages, corresponding to the Parts 1, 2 and 3 of the book: the unconnected manifold, the affinely connected manifold and the metrically connected manifold. The mathematical foundations given in these chapters are a masterly work of art, a pleasure to read for a scholar or a well-trained student, but scarcely useful as an introduction for a beginner. Right from the first appearance of the affine connexion it is made clear that no stringent reason can be given for assuming the affinity to be symmetric. The symmetric case is then discussed as an example which Einstein selected, because of its simplicity, for his original theory of gravitation. But the possibility of dropping this restriction is always kept in mind.

The main difficulty in the general theory is the proof that the field equations obtained by generalization from Einstein's gravitational equations are compatible. Schrödinger overcomes this difficulty by deriving the field equations from a variational principle; in this way the equality of the number of independent equations and of the number of unknown functions is automatically guaranteed. The central feature of these considerations is the fact that the conservation laws in general relativity are not valid as consequences of the field equations but are identities due to the invariance of the variational integral. The virtuosity displayed by Schrödinger in disentangling these complicated relations in such a way that they look quite simple and obvious makes the reading of the two last chapters of the book a particular delight. He shows that there is essentially only one reasonable generalization of Einstein's theory of gravitation obtained by dropping the symmetry of the affine and metric connexions, namely, that given by Einstein and Strauss. But he adds a new version of his own where, to begin with, only an affine connexion is postulated, while the metric is derived from it, and it is interesting that the equations obtained in this way are slightly more general: they reduce in the symmetric case to Einstein's equation with cosmological term. Schrödinger says: "The purely affine theory is the only one that produces this term in a natural, non-premeditated way".

The main aim of the book is certainly this demonstration that the way originally opened by Einstein leads uniquely to this theory, that no other possibilities exist. The logical argument has been brought to perfection, and its effect is even enhanced by the fact that Einstein and Schrödinger have independently reached the same result. No deviation from the straight path of reasoning is permitted, not even an illustration by one of the important applications of Einstein's theory of gravitation, things to be found in ordinary books on relativity. But if the reader expects to find some outlook on more familiar ground from the summit he is disappointed. The discussion of the results given in the last, very short section reveals that no special solution of the new field equations has yet been found which might suggest an application of physical interest, say the representation of particles by fields with point singularities. Not even a clear-cut separation of the various fields (gravitation represented by the symmetric part, electromagnetism by the skew part of the metric tensor) can be given, and one must be prepared to accept that none exists. In spite of this, Schrödinger declares "that the difficulty of finding exact solutions should not deter us from thinking further about these theories", because they are to his mind "the only natural generalisations of an eminently successful predecessor". Schrödinger, however, differs from Einstein in so far as he is strongly aware of the power and success of quantum mechanics. Therefore he does not, like Einstein, expect progress from complicated "particle solutions", but indicates that a study of plane sinoidal waves, as used in quantum mechanics, may be a reasonable, though not ideal approach.

This stimulating book can be recommended to all those who enjoy the intellectual pleasure of perfect logical penetration and condensed presentation of a theoretical structure derived from simple assumption, without demanding tangible results. MAX BORN

LIGHTNING

The Flight of Thunderbolts

By B. F. J. Schonland. Pp. viii+152+6 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1950.) 15*s*. net.

KNOWLEDGE of the mechanism of growth of lightning discharges has greatly advanced during recent years, largely as the result of the research carried out in South Africa by Dr. B. F. J. Schonland and his colleagues. While it had been known previously that a single lightning discharge generally consists of a number of separate strokes, which occur successively at short time-intervals along the same path, the direction of growth of the individual strokes was a matter of conjecture until 1933. In that year Dr. Schonland initiated a series of investigations in which lightning discharges were photographed by a rotating-lens camera of the form suggested by Sir Charles Boys. The results showed that the separate strokes could each be resolved into two components which are now known as the leader stroke and the return stroke. The former grows down from the cloud to ground to form an ionized track along which the return stroke, carrying the main current of the discharge, afterwards occurs. The characteristics of these luminous processes has been studied in great detail by Dr. Schonland and his colleagues. The associated electrical effects, as evinced in radio atmospherics, have also been recorded in later experiments and have been correlated with the visual growth of the discharge.

Dr. Schonland's experiments have provided a great stimulus to other research workers engaged in studies of lightning discharges, and his results have been confirmed and extended by investigators in other countries. Research on spark discharges has also been stimulated, and within a few years of the initial experiments on lightning the same sequence of leader and main stroke was observed to occur in sparks in the laboratory.

As a consequence of his very wide experience and knowledge of lightning phenomena, Dr. Schonland is eminently qualified to write on this subject, and his book will be welcomed by all who are interested in atmospheric electricity. The first two chapters give an entertaining account of early views and superstitions concerning lightning and of the historical development of lightning rods. The various forms

taken by lightning and some of its effects are discussed in Chapter 3, which is followed by two chapters dealing mainly with Dr. Schonland's own experiments on the luminous processes and the electrical characteristics of lightning discharges. Chapters 6 and 7 deal respectively with the methods of protection against lightning and the mechanisms of electrification of thunderclouds. In the final chapter, radio atmospherics, and their utilization for the location of thunderstorms by direction-finding methods, are discussed.

The book is clearly intended primarily to appeal to the general reader and is most successful in this respect. From the point of view of the specialist, however, it has the defect that the treatment is descriptive only and that few references are given to the published sources of the experimental work described. Nevertheless, it will be read and enjoyed by all specialists who like to have an elementary but authoritative account of the subject.

There is as yet no comprehensive book dealing with the physics of lightning discharges to which the research worker in the field, whether physicist, meteorologist or electrical engineer, can refer. It is to be hoped that the present book will prove to be the precursor of a research monograph on lightning by Dr. Schonland in which the admirable lucidity of the present volume will be combined with a deeper treatment of the subject. J. M. Meek

UNIVERSITIES OF THE BRITISH COMMONWEALTH

The Yearbook of the Universities of the Commonwealth, 1951

(Published for the Association of Universities of the British Commonwealth.) Pp. xxxi+1416. (London: G. Bell and Sons, Ltd., 1951.)

It is approximately a year since the previous edition of this "Yearbook" was published, and, as stated in the preface of the present volume, the aim is to issue future editions in the first quarter of each year. The book is published by the Association of Universities of the British Commonwealth and records details for all university institutions of the Commonwealth and not merely member institutions of the Association.

Besides the usual information on the lines of former issues, there are reports of events of outstanding interest which have occurred since the compilation of the previous edition. Thus the present publication records the inauguration of the University College of North Staffordshire and of the New South Wales University of Technology; Memorial University College, St. John's, has become the Memorial University of Newfoundland, and the University College of the Orange Free State has also been elevated to university status. For the first time, entries have been made for the Canadian institutions of Mount St. Vincent College, St. Dunstan's College, St. Joseph's College and Sir George Williams College; for the Indian Universities of Jammu and Kashmir, and Poona; and a full entry for the University of Malaya. As a result of the separation of the Republic of Ireland from the Commonwealth in 1949, the entries for the Universities of Eire have been placed in an appendix. A further alteration has resulted by the advent of the new General Certificate of Education, and Appendix 1, which deals with the matriculation requirements for United Kingdom universities, has been accordingly amended.

Of the main contents of the book, suffice it to say that there are the usual compilations relating to staff (approximately 28,000 names); general information; new events; introductory chapters on the history, regulations and practices of the universities in the different countries; and appendixes, dealing with a variety of subjects such as post-graduate awards tenable in the United Kingdom (which is also available as a separate pamphlet) and overseas, statistics on overseas students in the United Kingdom, the Inter-University Council for Higher Education in the Colonies, and information for those intending to study in the United States. An index of names and a general index round off the work.

Little further need be added about this excellent publication, except perhaps the rather obvious remark that for a volume of its size it contains an extraordinarily large amount of useful information.

EARTH WAVES

Earth Waves

By Prof. L. Don Leet. (Harvard Monographs in Applied Science, No. 2.) Pp. v+122. (Cambridge, Mass.: Harvard University Press; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 24*s.* net.

Much of the material of this instructive little book was collected by Prof. L. Don Leet for presentation as a course of eight lectures on the "Applications of Seismological Techniques to Engineering Problems" for the Lowell Institute of Boston. He has had wide experience in the use of the seismic method in prospecting for oil and bauxite, and has made a special study of the earth motion resulting from the atomic bomb test in New Mexico in 1945. Prof. Leet, who is professor of geology in Harvard University and seismologist in charge of Harvard Seismograph Station, has developed a three-component portable seismograph.

This book is a model of clarity, and, although first-year university standard in mathematics and physics is assumed, the reader need not have any prior knowledge of either geology or seismology. The book is well illustrated with line diagrams of apparatus, graphs, terrestrial sections and seismograms. It is divided into four chapters. The first deals largely with forced vibrations and the theory of the seismograph. The second chapter discusses the major types of waves observed in seismology, and it is to be noted that the symbols used for elastic constants are in accordance with the American Standards Publication *ASAZ* 10·6–1948 (American Society of Mechanical Engineers, New York, 1948). Some of these symbols differ from those in current use in the literature of seismology, though there need be no confusion since Prof. Leet is careful to list and explain all symbols used. Chapter 3 deals with the effect on earth waves of various earth structures commonly met with, and the consequent variation in seismograms. The final chapter treats of microseisms and the use of the tripartite seismograph installation to track storms at sea.

The whole work is a most valuable bridge between theoretical and practical seismology. Full references are given, there is an adequate index, and the printing and format leave little to be desired.

Ernest Tillotson

Réactions dans l'état solide

Colloques Internationaux du Centre National de la Recherche scientifique, 10. Pp. iv+222. (Paris: Centre National de la Recherche scientifique, 1950.) 1,100 francs.

DURING recent years there has been a welcome revival of the pre-war practice of holding international colloquia on scientific subjects, and, with the financial assistance of the Rockefeller Foundation, the Centre National de la Recherche scientifique has been particularly active in this direction. Under the auspices of that body one of the colloquia held during 1948 was on reactions in the solid state; it took place in Paris during October 1–6 and was attended by many distinguished chemists and physicists of various nationalities. These included Profs. G. Borelius and A. J. Hedvall (Sweden), Dr. E. J. W. Verwey (Netherlands) and Drs. P. W. Selwood and K. J. Laidler (United States). From Great Britain there were Dr. G. W. Brindley (Leeds), Prof. N. F. Mott and Prof. W. E. Garner, Drs. T. J. Gray and J. W. Mitchell (Bristol), Dr. R. M. Barrer (London) and Dr. D. M. C. MacEwan (Rothamsted). Belgium, France, Italy, Norway and Switzerland were also represented.

The proceedings of the colloquium have now been published. The volume consists of the text, in French, of the forty-odd papers and notes presented, together with a preface specially written by Profs. G. Chaudron and J. Bénard, the able organizers of the colloquium, and is a reprint of the January/February and March/April 1949 issues of the *Bulletin de la Société chimique de France*. Each paper is provided with a synopsis.

The concluding paper in the volume is by Prof. A. J. Hedvall, who was one of the pioneers in the study of reactions in the solid state and whose book "Reactionsfahigkeit fester Stoffe", published in 1938, is an authoritative work on the subject. In summing up the conclusions of the various other papers, Prof. Hedvall directs particular attention to the results obtained by magnetic methods such as those on the reactions of solids at transformation temperatures. He cites various examples of present technical applications of the chemistry of the solid state in the glass, ceramic and concrete industries and in powder metallurgy, and describes some of the research problems being undertaken in his own laboratory.

S. W.

Rocky Mountain Naturalists

By Joseph Ewan. Pp. xv+358+9 plates. (Denver, Colo.: University of Denver Press, 1950.) 5 dollars.

JOSEPH EWAN'S book falls into two parts. The first contains biographies of nine leading naturalists of the Rocky Mountain area, and the second a list, set out in dictionary form, of natural history collectors in the area. Among the biographies is one of Edwin James, the first botanist to visit Colorado to make a systematic collection of plants; John Charles Fremont, the general and botanist who stood as a candidate for the presidency; Charles Christopher Parry, the medical man who named so many Colorado mountains; Harry Norton Patterson, the Oquawka printer and botanist who did much collecting in the Gore Range area; Marcus Eugene Jones, the Iowa teacher of Latin who became an explorer and for more than sixty years travelled in search of rare plants; Edward Lee Greene, the Episcopalian rector of Georgetown, Colorado, who besides becoming well known as a writer, is also remembered for his tenacity in advocating the "fixity of species" against all Darwinian protagonists; Thomas Conrad Porter, professor of natural history at Lafayette College, who simultaneously acted as pastor of a Reformed Church and translator of Germanic literature; Eugene Penard, the Swiss protozoologist who compared the Rocky Mountain lakes with those of the Alps; and, finally, Prof. Theodore Dru Alison Cockerell, the friend of Alfred Russel Wallace who, though possessing no academic qualifications, came to be recognized as an authority on fish scales and bees.

This remarkable book is well written and should serve as a useful companion to Prof. S. W. Geiser's "Naturalists of the Frontier", with its accounts of distinguished naturalists of Texas and the Southwest.

Fundamentals of Organic Chemistry

A Brief Course for Students concerned with Biology, Medicine, Agriculture and Industry. By James Bryant Conant and Prof. Albert Harold Blatt. Pp. ix+413. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1950.) 30*s*. net.

THIS book differs from most elementary works on organic chemistry by beginning with alcohol and taking up hydrocarbons in the third chapter. The aliphatic substances are dealt with separately from the aromatic. The biochemical aspect is emphasized, in view of the type of reader contemplated, and the text is modern. Electronic theories are explained and used in the appropriate places. Quite complicated compounds, such as cholesterol, vitamins, porphyrins, and hormones find their place. The scope is not sufficient for degree students, but for medical students and those beginning organic chemistry the book should be attractive and stimulating. Some of the theoretical sections should interest more advanced students.

Atlas of Drawings of Chordate Anatomy

By Prof. Samuel Eddy. Pp. xi+150. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 28*s*. net.

THE American professor of zoology who has to deal with very large classes is driven to adopt any device that will save time and eliminate drudgery. To this end Prof. S. Eddy, with the help of Mrs. Louise Bush, has prepared 189 unlabelled drawings illustrating the morphology of the chief chordate types. By using these he claims that the student sees more, gets a general idea beforehand of what he should find in his dissections, and has a more clearly defined visual picture afterwards than his own laboured and often inaccurate drawings would have given him. Many British zoologists would disagree with him, for in Great Britain the hard way is preferred, which compels the student to observe before committing his ideas to paper, and trains his visual memory, so much more difficult to develop than the verbal memory.

The types employed in this work are *Amphioxus*, *Molgula*, the Ammocœte larva, dogfish shark, a teleost, *Necturus*, the alligator, tortoise, pigeon and cat. The outline drawings are on the whole excellent, and are sufficiently generalized to allow of additions and modifications. There are a few errors, as in the alligator skull (90), and the cat (venous system 151*A*), and it is somewhat confusing to find arteries sometimes white and sometimes black. Also, the description of the figures might be correlated better. Perforations allow of the rearrangement of the pages.

BRITAIN'S SCIENTIFIC SHRINES (2)

By Eng.-Captain EDGAR C. SMITH, O.B.E., R.N.

THE SOUTHERN COUNTIES

Of all the counties of England none is richer in scientific associations than Kent. From Greenwich, with its Royal Observatory, its Royal Naval College and its National Maritime Museum, to Folkestone, in the gardens of which stands the bronze statue of William Harvey, the countryside is full of places of interest. A 'Mecca' for the visiting astronomer, the Royal Greenwich Observatory—much of the work of which is being transferred to Herstmonceux, in Sussex—has many historic instruments preserved in Flamsteed House, built by Wren in 1675. Here have laboured the ten Astronomers Royal carrying out those fundamental observations which have made the Observatory the centre of the astronomical world. The chief promoter of the Observatory was Sir Jonas Moore (1617–79), surveyor-general of the Ordnance in the time of Charles II, and it was he who obtained for John Flamsteed the position of "Royal Observator". Moore's headquarters were in the Tower of London, and when he was buried there a salute of sixty-two guns was fired, marking his age. The list of the Astronomers Royal who in turn have directed the Observatory, with the dates of their appointments, is as follows: 1675, Rev. John Flamsteed; 1721, Edmond Halley; 1742, Rev. James Bradley; 1762, Rev. Nathaniel Bliss; 1765, Rev. Nevil Maskelyne; 1811, Rev. John Pond; 1835, Sir G. B. Airy; 1881, Sir William Christie; 1910, Sir Frank Dyson; 1933, Sir H. Spencer Jones. Some of these will be met with again in the course of the survey, but here it may be mentioned that Halley and Pond are buried together in Lee Churchyard, in a grave kept in order by the Admiralty.

Almost due south of Greenwich are Chislehurst, Farnborough and Down. One rector of Chislehurst was the scientifically minded Rev. Francis Wollaston, and in the churchyard, without any memorial, lies his son William Hyde Wollaston (1766–1828), "a mineralogist of the first order" and other things beside. Within six months of his death, the still more distinguished Thomas Young (1773–1829) was buried in the churchyard of St. Giles, Farnborough, and his memorial tablet is in the church. He had died in London, but was connected with Farnborough through his marriage with Eliza Maxwell, of Tubbendens House, a beauty spot then, but now almost derelict. It was thirteen years after Young's death that Darwin, then thirty-three, made Downe his home, leaving it but little until in 1882 his remains were borne to Westminster Abbey. Through the generosity of Sir George Buckston Browne (1850–1945), Down House and its grounds have been placed in the custody of the British Association, and visitors can now stroll through the field made famous by Darwin's observations on earthworms and see the study from which came the epoch-making book "On the Origin of Species by means of Natural Selection". Among the many naturalists who visited Darwin was Prof. Haeckel, twenty-five years his junior, and after the visit Haeckel described how Darwin's carriage carried him from the railway station to the house, where he was greeted by "a tall and venerable figure, with the broad shoulders of an Atlas supporting a world of thought. . . . The cordial, prepossessing expression of the whole face, the gentle mild voice, the slow, deliberate utterance, the natural and naïve train of ideas which marked his conversation captivated my whole heart in the first hour of our meeting. . . ."

Zigzagging across the county from Downe, a traveller can, if he wishes, see at Shoreham, in the Darenth Valley, the house and grave of the geologist Sir Joseph Prestwich (1812–96); at Dartford the tablet on the church to Richard Trevithick and at Northfleet the memorial erected by Swedish industrialists to Carl Daniel Ekman (1845–1904), the pioneer of the sulphite pulp industry. The village of Meopham, about six miles south of the Thames, was where the elder John Tradescant was married and the younger born, and in another direction is the village of Longfield, in the church of which members of the University of Cambridge placed a memorial window to the Rev. Thomas Plume (1630–1704). As vicar of Greenwich, he had known Flamsteed and had preached before Evelyn and Pepys, and as Archdeacon of Rochester he had lived at Longfield Court. At his death, he left nearly £2,000 for founding a chair of astronomy and erecting an observatory at Cambridge. The first Plumian professor was Newton's young colleague Roger Cotes, and among his successors have been Airy, Challis, Sir George Darwin (who was born at Down House) and Sir Arthur Eddington. The present occupant of the chair is Prof. Harold Jeffreys. In his benefactions, Plume was but following in the footsteps of his father, who had given a library to Malden, Essex, Plume's birthplace.

Plume's seventy-four years overlapped the lives of the younger John Tradescant (1608–62), of Elias Ashmole (1617–92) and of Dr. Robert Plot (1640–96), whom Oxford has cause to remember. Tradescant gave his collection of rarities to Ashmole, who added his own collection and gave the whole to the University, Plot becoming the first curator. An energetic man, writing on natural history, lecturing on chemistry and editing the *Philosophical Transactions*, Plot had his home at Sutton Baron, south-west of Sittingbourne, and on his memorial in Borden Church he is shown as a winged warrior with iron-tipped spear slaying a monster. Still further to the eastward, in the Faversham district, lies Ottenden Church and Ottenden Place, at the latter of which in 1729 the Charterhouse pensioner, Stephen Gray, with the Rev. Granville Wheler (1701–70), showed that electricity could be carried along hundreds of feet of thread. Wheler is buried in Ottenden Church, and his descendants still occupy Ottenden Place. Still deeper in the county, and near the Sussex border, is Hawkhurst, long the home of Sir John Herschel and his family. One day he had as his guests Adams and Leverrier, the discoverers of Neptune. He died at his house, Collingwood, on May 12, 1871, and was buried in Westminster Abbey beside Newton. By-passing the town of Ashford, the birthplace of the divine and mathematician, John Wallis (1616–1703), who lies in St. Mary's, Oxford, and travelling due east, Hythe and Folkestone are reached. In the former, on 31 High Street, is a tablet marking the birthplace of Sir Francis Pettit Smith (1808–74), the chief promoter of screw propulsion and one time curator at the Patent Office Museum, now a part of the Science Museum; while in the latter, in the parish

"church, is to be seen the brass to Harvey's mother, "a godly harmless woman, a quiet neighbour, a friendly matron", and on the cliffs Bruce Joy's statue of Harvey himself, who is depicted "holding the heart of a deer in one hand, while with the other he is feeling the pulsation of his own". August 6, 1881, was a gala day in Folkestone with a banquet, a concert, a holiday for the Harvey School and a train-load of visitors who came to see the statue unveiled by Richard Owen.

Entering the county of Sussex from the south of Kent, the visitor will find a series of towns and villages all containing reminders of the progress of science. First comes Rye, in the cemetery of which lies the Rev. C. M. Ramus (1821–95), who eighty years ago experimented with boats with stepped hulls, the earliest form of the hydroplane. Next comes Battle, in the vicinity of which the pioneer of the power loom, the Rev. Edmund Cartwright (1743–1823), and the pioneer of the electric telegraph, Sir Francis Ronalds (1788–1873), spent their later years. Cartwright's memorial is in Battle church, and that to Ronald in Battle cemetery. North-west of Battle lies the village of Brightling, and to the south-west is the magnificent fifteenth century brick castle of Herstmonceux, in the grounds of which are being set up the telescopes of the Royal Observatory. Brightling had its observatories more than a century ago, erected by the rich eccentric bachelor, "Jack" Fuller, of Rose Hill, now Brightling Park. The son of a parson and born in 1756, he did all sorts of strange things, for besides his two domes he erected Brightling Needle, and a score of years before he died built a great pyramid in the churchyard; beneath this pyramid he lies, the only inscription being the verse from Gray's "Elegy" ending: "The paths of glory lead but to the grave". He died in 1834, having the year before founded the Fullerian professorships of chemistry and physiology at the Royal Institution, Faraday holding one and Dr. Peter Mark Roget the other. Fuller's bust is in the church.

But science in Sussex has tended to centre around her geology, and at one time no name was better known than that of the Lewes surgeon Gideon Algernon Mantell (1790–1852), who explored, excavated and collected, and then wrote and lectured so that all could understand. He is buried in West Norwood Cemetery, London; but his Lewes home is marked by a tablet. "His gig and groom," wrote Gordon Hake, "were models as they waited at the door. His coat of arms embraced your vision as it shone in the fanlight and whispered of greatness within. He was tall, graciously graceful and flexible, a naturalist, realizing his own lordship of creation." Three-quarters of a century after Mantell came the Lewes solicitor, Charles Dawson (1864–1916), a Lancashire man, who in 1912 in the old river gravel at Piltdown, near Fletching, about seven miles north of Lewes, found parts of the Piltdown skull, *Eoanthropus dawsoni*, as Smith Woodward christened it. That spot, too, is marked by a tablet.

Before leaving Sussex a word should be said of Sir George Wyndham, Earl of Egremont (1751–1837), of Petworth Castle, in West Sussex, who from his school-days displayed the characteristics of a liberal-minded patrician. He once aided Mantell; but long before that, in 1784, he had as a guest the Hungarian astronomer Baron von Zach (1754–1832), and it was von Zach who, among a heap of old stable records at the Castle, found the astronomical papers of the Elizabethan mathematician Thomas Harriot (1560–1621), one of the first in England to use a telescope and observe sunspots.

Travelling northward across the Downs and the Weald of Sussex, so thoroughly explored by Mantell, just inside the border of Surrey are Burstow to the east and Hindhead and Haslemere to the west, the latter being the last home of the physicist John Tyndall, who died there at the age of seventy-three on December 4, 1893, through a tragic mistake. Irish by birth and temperament, he became as a son to Faraday at the Royal Institution, and succeeded him as superintendent. He had married rather late in life and his widow survived him forty-seven years, passing away in August 1940 at the age of ninety-five. As a mountaineer, Tyndall had made the first ascent of the Weisshorn, and within sight of the mountain Mrs. Tyndall set up a granite monolith to his memory, and later on in 1931 gave to the National Trust the Tyndall Wood at Haslemere.

Hindhead and Haslemere are in the uplands of Surrey; but Burstow is in the flat agricultural district around Horley. Flamsteed was rector of this parish from 1684 until his death. With his wife he lies in the chancel of the church, where a window was erected to his memory in 1887 by a local resident, J. T. Tustin, and from the steps of this chancel Sir H. Spencer Jones delivered an address at a service held on August 18, 1946, to commemorate the tercentenary of Flamsteed's birth. Farther north, between Dorking and Guildford, lies Albury, the scene of the labours of the Rev. William Oughtred (1575–1660), friend of many mathematicians, who during his fifty peaceful years as rector wrote among other works his "Clavis Mathematicæ", a much esteemed book which gave the world the algebraical signs '×' and '::'. All around this district are beautiful scenes and fine gardens, and not far away across the Guildford–London road are the Wisley Gardens of the Royal Horticultural Society. The other great Surrey Gardens, the Royal Botanic Gardens, founded in 1759 and associated with the work of Aiton, the Hookers, Thiselton-Dyer and others, are at Kew, and it is this corner of the county which is richest in scientific interest. As early as 1725, Samuel Molyneux (1689–1728) set up a telescope at Kew Green to test some of Hooke's views regarding the distance of the stars, and here he was sometimes joined by Bradley. In 1758 George III, anxious to observe the transit of Venus of the following year, founded his own observatory at Kew and appointed the elder Stephen Demainbray (1710–82) as his astronomer. Not much was achieved in astronomy at the observatory; but in 1843 it came under the control, at first, of the British Association and then of the Royal Society, and ever since has been widely known for its meteorological work; among its directors have been Ronalds, Balfour Stewart, Charles Chree and also G. M. and F. J. W. Whipple.

Mortlake, Richmond and Kingston, too, have something for the man of science. At Mortlake are buried the Elizabethan alchemist Dr. John Dee (1527–1608), the astrologer and almanac maker John Partridge (1644–1715) and the nineteenth century sanitary reformer Sir Edwin Chadwick (1800–90). At Sheen Lodge, Richmond, Sir Richard Owen, whose body lies in Ham churchyard, spent many years of his life, and in Kingston Museum are preserved some of the relics of Edward Muybridge, one of the pioneers of the cinema.

It may well be that some visitors to the South Bank Exhibition will admire London's bridges, and

for these it is worth mentioning that in the churchyard and church at Chipstead, south of Croydon, Surrey, are the tomb and monument to Sir Edward Banks (1770–1835), the foremost civil engineering contractor of his day, who built to the designs of John Rennie the old Southwark and Waterloo Bridges and the present London Bridge, all three of which are depicted on his monument.

If Berkshire, Hampshire, Wiltshire and Dorset cannot claim so many scientific shrines as the three south-eastern counties, no naturalist will overlook Selborne in Hampshire, the home of Gilbert White (1720–93), where the National Trust owns some 240 acres over which White so often strolled; no photographer will willingly miss the beauties of the home of Fox Talbot (1800–77), Lacock village and Lacock Abbey, in Wiltshire, generously given to the Trust by Miss Matilda Talbot, his granddaughter; and no geologist touring Dorset will fail to visit Lyme Regis church and see the window erected by the Geological Society to the memory of Mary Anning (1799–1847), who as a girl of twelve obtained from the cliffs the fossil remains of an *Ichthyosaurus*. Lyme Regis was also the birthplace of John Gould (1804–81), the traveller and ornithologist, one time curator of the Museum of the Zoological Society. In the same county, in an old Elizabethan mansion at Stalbridge, Robert Boyle passed some of his youth, in Purse Candle church lies Harvey's friend, Nathaniel Highmore (1613–85), and at Winsford Eagle, another famous medical man, Thomas Sydenham (1624–89), was born. The most popular London practitioner of his time, he was buried in St. James's, Piccadilly, now in ruins. The tablet over his grave was erected by the Royal College of Physicians.

The oldest Berkshire man of science of note appears to have been John Blagrave (d. 1614), who after studying at St. John's College, Oxford, retired to his home near Reading, writing books and recommending mathematical studies "to Gentlemen of Abilities and Leizure, as they were not mere Amusements for Scholars and speculative Persons, but of general Advantage to the necessary Affairs and Business of Life". He wrote on dialling, the staff and the astrolabe, and his monument in the church of St. Lawrence, Reading, shows a man in cloak, cassock and ruff, with a globe in one hand and a quadrant in the other. Sir Samuel Morland (1625–95) was another Berkshire man, his birthplace being Sulhamstead Bannister, seven miles from Reading. There was no quiet retirement for him, for he liked to be in the limelight, and if not engaged in public affairs was filling his Vauxhall house and later his Hammersmith house with ingenious mechanisms of all sorts. He had the misfortune to lose his sight before he died, and he was buried in Hammersmith Chapel. He was four times married and two of his wives, Carola (d. 1674) and Ann (d. 1680), are commemorated in Westminster Abbey. Berkshire was also the first home of Francis Baily (1774–1844) and the last of David Gregory (1661–1708) and William Lassell (1799–1880), all astronomers and all Fellows of the Royal Society. Baily was the son of a Newbury banker; but his days were spent in London, where he helped to found the Royal Astronomical Society, of which he was president four times. Lassell was one of his successors in the chair; but he began life as a Lancashire brewer. He had several observatories, one at Malta; but the last was at Maidenhead, where he died on October 5, 1880. There was no astronomical society in Gregory's day; but he did good work as the Savilian professor at Oxford and counted among his friends Flamsteed and Newton. There is a handsome memorial to him in St. Mary's Church at Maidenhead.

Leaving Berkshire for Hampshire, near a line drawn due south from Reading, will be found the village of Eversley and then the town of Alton and the village of Selborne. In the time of the Rev. Charles Kingsley (1819–75), the rectory and the church at Eversley and the surrounding district were often the object of a pilgrimage, for Kingsley would not only have every man a Christian but also a naturalist. It was this that gave birth to his "Water Babies". His admirers came from every age and every class, and after his burial at Eversley on January 28, 1875, a naval officer wrote: "I have been at many State funerals but never did I see such a sight as Charles Kingsley's". He must have known the town of Alton, with its botanical reputation; but he could only have known William Curtis (1746–99), who was born there, through his writings. For most of his life Curtis was an apothecary at 51 Gracechurch Street, London, and the plaque now on the site of his house is one of the very few to men of science in the City. Curtis was buried in St. Mary's churchyard, Battersea, and at the commemoration of his bicentenary in 1946 steps were taken to restore his tomb. Of Selborne it is not necessary to write, for who has not dipped into White's "Natural History"? Farther south in the county, near Winchester, is Sparsholt, where Sir George Buckston Browne in 1945 was laid beside his wife, while still farther south is the magnificent Abbey at Romsey, in which are commemorated two most versatile and ingenious men, Sir William Petty (1623–87), the son of a Romsey clothier, and the Rev. E. L. Berthon (1813–99), vicar of the parish for many years. All who know about ships have heard of Berthon's screw propeller and collapsible boats, if not his nautical log; but he was also expert with telescopes and microscopes. Petty, too, knew something of ships, having served in the Navy; but anatomy, physic, music, surveying and economics all occupied his time and thoughts, and he has been called "The Father of Political Economy".

Though the home of Fox Talbot will probably be the favourite scientific shrine in Wiltshire, the county can claim among its notable men at least three who were original Fellows of the Royal Society. The first of these is Sir Christopher Wren (1632–1723), who was born at East Knoyle, near Salisbury; the second, Dr. Thomas Willis (1621–75), who was born at Great Bedwyn, not far from Marlborough, and who was buried in Westminster Abbey at a cost of little short of £500; and the third, Seth Ward (1617–89), a native of Hertfordshire, who died in London but is buried and commemorated in Salisbury Cathedral. William Oughtred was one of his instructors, and John Wallis one of his collaborators. He was first Savilian professor of astronomy (1649–61), then Dean and Bishop of Exeter (1661–67) and finally Bishop of Salisbury. Then, too, Wiltshire can claim not only the Talbot family but also the Story and Maskelyne families, from which came Nevil Maskelyne (1732–1811), the Astronomer Royal, and his grandson, Nevil Story-Maskelyne (1823–1911), whose services to mineralogy at the British Museum and Oxford will long be remembered. The home of the Story-Maskelynes was near Swindon, and its annals have been recorded in the late Mrs. Arnold-Forster's "Basset Down". Wiltshire was also the last home of Sir Oliver Lodge, who died on August 22, 1940, and was buried at Wilsford, six miles south of Devizes.

SUBSTITUTION OF NITRIC FOR SULPHURIC ACID IN THE PRODUCTION OF PHOSPHATE FERTILIZERS

By Dr. G. R. DAVIES
Chemical Research Laboratory, Teddington

SULPHURIC acid is, perhaps, the most important of all chemicals, and the amount consumed usually provides a reliable index to the industrial virility of a country. In the United Kingdom the annual production of the acid has increased steadily over the years, rising in the past decade from about 1,200,000 tons to more than 1,800,000 tons in 1950. More than fifty per cent of the recent production has been made from sulphur, the remainder being manufactured from pyrites, spent oxide, zinc concentrates and anhydrite. Native sulphur is the preferred raw material because of its high purity, low shipping costs and because of the lesser operating costs of plants burning sulphur as compared with those using pyrites. Considerable concern has therefore been caused in recent months by the statements which have been issued regarding the limited extent of the reserves of brimstone in the United States, which is the major producer of native sulphur. At the present rates of consumption these reserves may last only ten or eleven years. This has led the United States to reduce its exports, and British imports of sulphur have therefore been decreased by some thirty per cent. Although the reserve position in regard to pyrites is much more secure, yet any conversion of sulphur-burning plants to enable them to use pyrites must cause serious dislocation and must require some years to complete. The present position therefore calls for strict economy in the use of sulphuric acid.

The largest consumer of the acid in Britain is the fertilizer industry, which last year used 435,500 tons in the manufacture of superphosphate, while a further 260,000 tons was employed in the manufacture of ammonium sulphate. A reduced production of sulphuric acid must lead to a decrease in the manufacture of artificial fertilizer and to a lowered productivity of British farm lands. Of course, there are numerous other users of sulphuric acid, such as the rayon industry, of which much has been heard recently and which itself consumes more than 200,000 tons of acid annually.

Because of the difficulties that might arise in maintaining adequate supplies of sulphuric acid to the fertilizer industry, the Chemical Research Laboratory, Teddington, has been studying for the past two years the possibility of making phosphate fertilizers by methods which might effect a saving in the amount of sulphuric acid used. The most obvious alternative to sulphuric acid is nitric acid, for its production does not call for the use of imported raw materials, while the nitrogen value of the acid is recoverable in the form of a nitrogenous fertilizer, and this offsets to some extent the greater cost of the acid as compared with sulphuric acid. Unfortunately, the action of nitric acid on phosphate rock leads to the production of a fertilizer containing much calcium nitrate, which is a highly hygroscopic substance and causes the fertilizer to become damp and difficult to use. Consequently, the work at the Chemical Research Laboratory has largely been confined to the use of mixtures of nitric and sulphuric acids. The action of these acids on phosphate rock leads to the formation of monocalcium phosphate, calcium sulphate and calcium nitrate, and there seemed the possibility that the inert calcium sulphate might so coat and protect the calcium nitrate as to prevent it absorbing moisture or, at least, that it would so slow down the rate of adsorption of moisture as to render the product usable without further treatment. Actually, it has been found that products made in this way are more stable to atmospheric conditions than when nitric acid is used alone. The maximum amount of nitric acid which can be tolerated in order to give a product having a low absorption of moisture is when the mixture of acids contains about 2 mol. of nitric acid to one of sulphuric. Even with this mixture of acids the fertilizer made from it is somewhat hygroscopic if the theoretical amount of acid is used to decompose the rock completely, but when only eighty per cent of this amount is used the material does not pick up any appreciable amount of moisture at relative humidities below seventy per cent. The reaction between the phosphate rock and nitric–sulphuric acid mixtures is quite vigorous and goes to completion much more rapidly than when sulphuric acid is used alone as in ordinary superphosphate manufacture. The product also sets quickly to a dry, crumbly product, although it will dry out a little further in the course of a day or two. The fertilizer made in this way contains about 18 per cent of phosphate (reckoned as P_2O_5), of which 86 per cent is water-soluble, while 96 per cent is dissolved by 2 per cent nitric acid. The nitrogen content is about 4 per cent. There is very little evolution of hydrofluoric acid during the reaction and virtually no loss of nitric acid as nitrous fumes.

Attempts have been made to include potassium chloride in order to provide a complete fertilizer; but with any substantial addition of this substance the products are more sensitive to atmosphere moisture.

A report on the work has been presented to the Fertilizer Manufacturers' Association.

SCIENCE AND BREWING

WHETHER brewing is an art or a science continues to be a question for debate; but it cannot be doubted that the impact of science on the brewing industry is becoming ever more insistent. Economic conditions are enforcing a more considered use of raw materials and plant; on the other hand, the selection of new barleys suited to changing agricultural conditions, malting for brewing, the selection and conservation of desirable yeasts, the development of acceptable disease-resistant hops and a better understanding of the many processes of mashing, fermentation, maturation and others making up what is colloquially known as brewing, are only a few of the numerous questions calling for scientific investigation. It was timely, therefore, when the Microbiological Group of the Society of Chemical Industry, the Incorporated Brewers' Guild and the Royal Microscopical Society held a symposium on brewing on March 14 in the Chemistry Department, King's College, Newcastle upon Tyne.

In an opening contribution on "Beer and the Biochemist", M. H. Van Gruisen (Newcastle Breweries, Ltd.) paid tribute to the help which science has given and is giving to the brewer in enabling him to produce a stable and uniform product from unstable

and variable raw materials. Thus, malting barley has received much attention from agriculturists and plant breeders, with the result that, through selection and breeding within the past fifty years, the brewers' extract of normal malts has risen by four or five pounds per quarter, while at the same time the farmers' yield per acre has also increased.

In the hop garden the main task has been the continued warfare against various pests and diseases to which the plant is prone. Wilt-resistant varieties have been bred, and these are at present undergoing large-scale brewing trials. Hops with a high resin content have also been reared to replace American hops which are no longer available.

Finally, of the ingredients of the brew, the water or 'liquor', the composition of which is often thought to account for the pre-eminence in brewing of certain areas, such as that of Burton-on-Trent, must not be overlooked. Now, with analytical methods available and the effects of minor constituents on various reactions in the brewing process better understood, breweries with less-favourable water supplies are able to make the necessary adjustments.

From the biochemical point of view, the brewing process is in effect the production of a culture medium for yeast. The need for a thorough understanding of wort constituents and yeast nutrition has led to a considerable volume of research on starch and plant proteins.

During malting, enzyme systems develop which in the mash tun break down the starch of the original barley corn into maltose and dextrins of various degrees of complexity. The ratio of these fermentable to non-fermentable products may be controlled by mashing conditions and are of importance to the brewer. Maltose, by its breakdown to alcohol and carbon dioxide, yields to the yeast the energy required for reproduction, while the unfermentable dextrins give character to the finished beer.

The protein breakdown largely occurs during malting. The amino-acids and some of the very simple di- and tri-peptides are potentially utilizable by the yeast as nitrogen sources for building new cells. These amino-acids may be used directly or may supply nitrogen by transamination or deamination, by the Ehrlich mechanism, to give the alcohol corresponding to the amino-acid. This factor is of some importance, as the resulting higher alcohols contribute to the aroma of the beer. Of the more complex nitrogenous products, most are removed during the brewing process, but the β-globulin fraction survives in combined form with hop tannin. Albumen degradation products are probably responsible for the head-retaining properties of the beer, but globulin tannate is the cause of chill and oxygen hazes which are particularly detrimental to bottled beers.

In a second contribution, "Enzymes and their Significance in Brewing" were discussed by Prof. I. A. Preece (Heriot-Watt College, Edinburgh). He said that, if the term brewing be restricted to mean the preparation of a specialized medium for yeast growth and fermentation, the enzymes to be considered were those of barley and malt, and the reactions those concerned in malting and mashing; the subsequent boiling of the wort with hops inactivates residual enzymes and stabilizes the composition of the fermentable medium.

The enzymes concerned may be considered to form two groups, of which the first contains the general metabolic enzymes already present in the raw barley. Particular significance here is attached to the dehydrogenase system, the activity of which in living corns permits determination of the germinative capacity of a barley sample, so giving rapid distinction between dead corns and those which are merely dormant. However, since the power to germinate is not accurately paralleled by retention of dehydrogenase activity, samples which have suffered a moderate degree of heat damage may give misleading results in the test. Other enzyme systems in this general group include: catalase, which again shows differences of behaviour in living and dead corns; phosphorylase, associated with starch synthesis; and the interlinked systems concerned in aerobic and anaerobic energy release.

The second group of special metabolic enzymes includes many where reversibility of action has not been demonstrated; to some extent, these enzymes resemble those of the animal digestive tract. It is a main purpose of malting to allow development of these enzymes, or—if they are already present in the raw grain—to facilitate their extraction in the subsequent mashing. A second main purpose is the modification of the hard barley grain, the intense enzymic activity during germination causing hydrolysis of cell-wall and related materials, so permitting adequate crushing of the grain and reducing the viscosity of the extract obtainable; at the same time, a proportion of the nitrogenous material is hydrolysed to provide yeast-feeding compounds, and α-amylase is produced in amounts which permit speedy saccharification of starch to be achieved in the mashing process. The kiln treatment of the germinated grain produces a malt dry enough for safe storage, stabilizes its composition, allows control of the proportions of the various enzymes present, and adds colour and flavour.

Little cytolysis or proteolysis occurs during the British infusion system of mashing, and quantitatively the main enzymic reaction is starch hydrolysis. This produces fermentable sugars (glucose, maltose, maltotriose) and unfermentable dextrins (branched and unbranched α-dextrins) as a result of the joint activity of α- and β-amylases. The heat instability of the latter near the temperature of an infusion mash (for example, 65° C.) permits a high measure of control of the proportions of fermentable and unfermentable materials formed, since the production of maltose by β-amylase in mashing decreases sharply as the temperature is raised, while the α-amylase activity is but little affected in the range 63–67° C.

In the final session, Dr. A. H. Cook (Brewing Industry Research Foundation) spoke on "The Significance of Microbiological Research in Brewing". This significance does not so much extend into the past as reach out into the future; despite three centuries of microbiological history, this science has only acquired any coherent form as a result of a few epoch-making advances, such as that of the antibiotic field, of the comparatively recent past.

Consideration shows that antibiotics may have some, if limited, use in the brewery. Subtilin is receiving attention as a preservative of foodstuffs, while antibiotics in a more limited sense may play a part in the orderly development of the individual organisms comprising a normal brewers' yeast; a prominent example is the development of *Brettanomyces* species in maturing cultures of *Saccharomyces cerevisiæ*. Although not of microbial origin, humulone and lupulone have an antimicrobial action, and the suggestion has been made that lupulone may offer a

means of ingress to the antitubercular field. In adding to such approaches, many physical methods of controlling yeast and bacterial growth in the brewery have still to be explored. Ultra-violet sterilization has not been without success; ultrasonic treatment may be of value in this way as well as in rapid 'conditioning' (so far as protein precipitation is concerned), and cathode-ray treatment, now receiving intensive examination in processing foods, may provide another sterilization treatment lacking the disadvantages of pasteurization.

Turning more particularly to some aspects of brewery fermentation, only very recently has there become available even a partial view of the carbohydrates and of the amino-acids and other nitrogenous constituents of brewers' wort, as well as of their value as yeast nutrients and substrates. A brewery yeast, however, must obviously effect a composite fermentation, and in studying the component parts the National Collection of Yeast Cultures, which will be a responsibility of the Brewing Industry Research Foundation, seems likely in many instances to play an important part. Subsidiary collections of brewers' yeasts and of genetically pure and hybrid yeasts should have a peculiar research interest. The hybridization of yeast has only recently been intensively studied, mainly by Winge and his associates, who have provided much of the available data on the sporing and on the haplo- and diplo-phases of certain species of *Saccharomyces*. This work has proved valuable in the selection of hybrids for simple fermentation yeasts, but its exploitation in the brewery has hitherto been less marked. Such exploitation is, however, brought nearer by recent work of Thorne, who has succeeded in hybridizing several British top-fermentation brewery yeasts. Selection of the hybrids reveals that flocculence is a genetically controlled character. The observed segregation of the readily mutating hybrids makes it appear that not less than three genes are concerned with the appearance of flocculence, while still another seems concerned with inhibiting the expression of flocculence.

There are innumerable other points at which microbiology touches brewing. These range from the use of insecticidal washes in hop culture to the importance of wild yeasts in brewery casks, from the disposal of potentially toxic materials by yeasts to the formation of valuable vitamins. These are but a few of the problems which research in the not too distant future should do much to answer.

OBITUARIES

Mr. J. W. Tutcher

By the death, on April 11, of John William Tutcher, in his ninety-third year, geology has lost one of its outstanding amateur workers. He will be remembered particularly for his many contributions to the study of the palæontology and stratigraphy of the Jurassic rocks of the Bristol district, and for his pioneer work in scientific photography.

Until recent years Mr. Tutcher carried on business as a bootmaker in Bristol; but most of his leisure was devoted to geology. In his younger days this frequently involved cycling out before business hours to the quarries of Dundry Hill and, when some particularly interesting bed was being uncovered, walking back with his cycle loaded with specimens. When his own lameness is borne in mind, one could only marvel at his success in bringing together and preparing the collections which overflowed into all parts of his home. Apart from numerous specimens which found their way into other museums, the Bristol City Museum has more than 20,000 fossils from the Tutcher Collection, all with details of locality and precise horizon. At all times his specimens were placed at the disposal of other geologists, and many younger geologists owe much to his ready help. He wrote comparatively little himself, unless very strongly persuaded; but he contributed several papers to the *Proceedings of the Bristol Naturalists' Society* and to the *Quarterly Journal of the Geological Society*. For many years he worked with the late S. S. Buckman, and his name appears on the title-pages of the seven volumes of "Yorkshire Type Ammonites" and "Type Ammonites", for which he provided most of the photographs. But his contribution, as Buckman always freely admitted, was not confined to the preparation of plates; his great knowledge of the detailed stratigraphy of the Lias in particular was of great service to his collaborator.

Mr. Tutcher was probably the first person in Britain to build a piece of equipment for the lighting and photography of fossils, a work in which he acquired such skill that, twenty years ago, it was nearly always possible, on skimming a volume of geological papers, to pick out by their high quality the illustrations prepared by Tutcher; for in this field he was always ready to help others, and it has been estimated that he provided for reproduction photographs of several thousand fossils.

Mr. Tutcher was awarded the Lyell Fund by the Geological Society in 1924, and received the honorary degree of master of science from the University of Bristol in 1927. He was for many years a prominent member of the Bristol Naturalists' Society, of which he became president. He was also president of the South-Western Naturalists' Union. His modesty and kindness will long be remembered by those who were privileged to work with him. A. E. Trueman

Prof. F. K. Kleine

Prof. Friedrich Karl Kleine, a distinguished pioneer and leader in the field of research into tropical diseases of man and animals in Africa, died in Johannesburg on March 22 at the age of eighty-one.

Kleine was born on May 14, 1869, at Stralsund, a Baltic port of Germany. He was the son of a medical practitioner, and early decided to follow his father's profession, entering the University of Halle as a medical student. After qualifying, he worked at the Pharmacological Institute in Halle, and at the University Clinic in Kiel, and served also for a time in the Army Sanitary Service. In 1900 he was appointed to the staff of the Institute for Infectious Diseases in Berlin, and there became personal assistant to Prof. Robert Koch, the discoverer of the tubercle bacillus and of the cholera vibrio. In 1903 Kleine went with Koch to Southern Rhodesia to investigate a disease, thought to be redwater, in cattle, which was causing great economic losses. Their investigations showed the disease to be tick-borne and distinct from redwater, and they named it 'African coast fever'. This finding led Kleine to become one of the first to work on the developmental stages of the parasite of tick fever in dogs—a story which is still not properly elucidated. During 1906–7

Kleine was seconded for service with the German Sleeping Sickness Expedition in East Africa under Koch's leadership. His particular researches related to preventive measures against the disease. Later he returned to East Africa as leader of a campaign against sleeping sickness. On this visit he made the important discovery that the trypanosome causing the disease is not carried from the sick to the healthy by the tsetse fly in a direct mechanical way, as had been believed, but undergoes a fairly prolonged cycle of development in the fly after the fly has fed on infected blood. This discovery by Kleine opened a new road to investigators, and led to many advances in knowledge of the epidemiology of trypanosome diseases.

After an interruption to research caused by the First World War, Kleine was granted permission in 1921 to visit Northern Rhodesia and the Belgian Congo to test a new drug, 'Bayer 205' ('germanin'), in human and animal trypanosomiasis. In 1926 he was nominated as the German delegate on the League of Nations International Commission on Human Trypanosomiasis, and, working in Uganda, Kenya and Tanganyika, he investigated problems of immunity against trypanosomes in natives living in chronic foci of sleeping sickness.

In 1933 Kleine was elected president of the Robert Koch Institute in Berlin, where he continued his researches on relapsing fever, foot-and-mouth disease, rinderpest, trypanosomiasis and other tropical and veterinary diseases, revisiting Southern Rhodesia and East Africa during 1934–35, and South Africa during 1936–37. In 1947 he retired to South Africa, where he spent the last days of his life.

Kleine's patent honesty, his conscientiousness in research, his sense of humour, and unvarying courtesy won for him many friends among his colleagues and British co-workers in Africa. He married Hanna Ockelmann, who accompanied him on his many journeys and assisted him in his scientific work during the last thirty years of his life, and who survives him. They had one son, who was killed in Bucharest in the Second World War.

R. L. Sheppard

Mr. A. S. E. Ackermann

Mr. A. S. E. Ackermann died at the age of eighty-three on April 7. He practised as a consulting engineer in Westminster and his work covered a wide range.

Though born in London, Ackermann received his first training at the South African College, now the University of Cape Town. Later, in London, he was one of the early students at the City and Guilds College, where, after gaining his associateship in civil and mechanical engineering, he was employed by Prof. W. C. Unwin as his assistant, and many years later was elected a Fellow of the College.

Ackermann made good use of his scientific training and was always an ardent advocate of adequate qualification for all practising in any branch of science. He took the degree of B.Sc.(Eng.) and later served as deputy chairman of Convocation of the University of London, after having been for eleven years honorary general secretary of the London Graduates Association. He was secretary of the Society of Engineers for more than thirty years, and for several years was the honorary general secretary of the British Section of the International Association of Journalists.

In the many branches of engineering in which he worked and gave advice, Ackermann's approach was always scientific and logical, and for that reason he was an extremely good expert witness and was successful in cases relating to noise and smoke nuisance and in 'ancient lights' disputes. He believed that it was possible to do effective practical research without the use of complex apparatus, and gave proof of this in 1919 when he did pioneer work investigating the physical properties of clay, using only household appliances. The results were given in three papers published by the Society of Engineers, in which he established a critical point which he called 'the pressure of fluidity'.

In about 1907 Ackermann became interested in the development of power from solar energy, and as engineer to a syndicate he was responsible for the designs and experiments made with several plants. The first of these was tested in America, and the final plant, which was tested in Egypt, was more elaborate; by using focusing mirrors, it produced steam at a low pressure, which was supplied to a specially designed engine. A full description of this test, together with particulars of all earlier attempts to develop solar energy, was given in a paper by Ackermann published by the Society of Engineers in 1914.

The examination of commonly accepted statements which could be checked and refuted on a scientific basis attracted Ackermann, and the collection of such cases became an absorbing interest to him. In 1907 he published a collection of these cases under the title "Popular Fallacies", which proved very successful. He continued to collect fallacies in ever widening fields, and in the fourth edition of this work, published in 1950, no less than two thousand are treated and classified under twenty-seven headings.

Ackermann was a familiar figure at the meetings of numerous engineering and scientific societies and will be missed by many. He married in 1901, and his widow and two daughters survive him.

J. S. Wilson

Dr. H. J. Finlay

Micropalæontology in New Zealand has suffered a serious loss in the sudden death of Dr. Harold John Finlay at his home in Karori, Wellington, on April 7. Born at Cronilla, India, in 1901, Finlay went with his parents to Dunedin, New Zealand, within a few years. He received his primary and secondary education at the Normal School there, and, after a brilliant career at the University of Otago, graduated M.Sc. in 1921 with first-class honours in chemistry. For two years, as John Edmond Fellow, he did post-graduate work in chemistry, and for the next three years was National Research Scholar in palæontology under Prof. W. N. Benson. For the following three years he was biologist to the Fisheries Branch of the Marine Department.

During the period 1923–31, Finlay published about thirty papers on molluscan systematics, mostly in the *Transactions of the New Zealand Institute* (later, *Trans. Roy. Soc. N.Z.*) but some in the *Proceedings of the Malacological Society of London*. In 1926 he was awarded the Hamilton Prize for his published work, and in the following year he obtained his D.Sc. with an outstanding "Further Commentary on N.Z. Molluscan Systematics" (*Trans. N.Z. Inst.*, **57**, 320). Other important papers are, "New Shells from N.Z.

Tertiary Beds, Parts 1–3" (*Trans. N.Z. Inst.*, **55**; **56**; **61**); and "Recent Mollusca of the Chatham Islands" (*Trans. N.Z. Inst.*, **59**).

During 1933 and 1934, as part of its oil prospecting work, Taranaki Oilfields and Vacuum Oil Co. employed Finlay to take up a study of the Cretaceous and Tertiary Foraminifera. In this new field his keen mind and ability for intense application, together with his schooling in molluscan systematics, soon produced highly significant stratigraphical results. In 1937 he was appointed micropalæontologist to the N.Z. Geological Survey, and in the next ten years he revolutionized the status of Foraminifera in the stratigraphy of New Zealand with the following papers: "New Zealand Foraminifera: Key Species in Stratigraphy, Nos. 1–5" (*Trans. Roy. Soc. N.Z.*, **68**; **69**; and *N.Z. J. Sci. Tech.*, **28**); "The Foraminiferal Evidence for Tertiary Trans-Tasman Correlation" (*Trans. Roy. Soc. N.Z.*, **76**); and, with J. Marwick, "The Divisions of the Upper Cretaceous and Tertiary in New Zealand" (*Trans. Roy. Soc. N.Z.*, **70**).

Finlay was elected Fellow of the Royal Society of New Zealand in 1939, and received from the Society the Hector Medal and Award in 1941.

In addition to his scientific activities, Finlay was an accomplished musician, in later years devoting considerable time to serious composition. A prelude and fugue of his was publicly performed and broadcast by the New Zealand National Orchestra, and some chamber music trios have been broadcast by instrumental groups.

J. Marwick

NEWS and VIEWS

Symons Memorial Medal: Sir Geoffrey Taylor, F.R.S.

The Symons Memorial Medal of the Royal Meteorological Society, which is awarded biennially for distinguished work in meteorological science, has been conferred this year on Sir Geoffrey Taylor in recognition of his classical work on atmospheric turbulence. Sir Geoffrey's first contribution to the subject arose from his participation as meteorologist in the *Scotia* Expedition to the Grand Bank of Newfoundland in 1913. This expedition followed the loss of the *Titanic* from collision with an iceberg in foggy weather in the Atlantic, and his work was concerned with the modification of temperature and humidity in an air mass by turbulence as it passed out to sea from a continental area or over a progressively colder sea—Grand Bank fog is commonly produced in the warm moist south-easterly air stream which encounters a very high gradient of surface temperature in the ice-chilled waters of the Grand Bank area. He made kite observations from the *Scotia* and was able to interpret them in terms of a theory of turbulence which effectively anticipated Prandtl's mixing-length theory of turbulence. Later papers followed in the *Proceedings* and *Philosophical Transactions of the Royal Society*, dealing with momentum transfer by turbulence, the drag of the earth on the wind and the variation of wind with height in the planetary boundary layer. In 1917 Sir Geoffrey gave a very full discussion of the problem of the formation of fog over land as well as at sea, and devised a fog-prediction diagram for Kew Observatory, using methods which have since been elaborated by others. Later he designed a very simple but elegant bi-directional vane for recording turbulent fluctuations in the wind at right angles to the mean motion, and reported on his findings with this instrument in his Symons Memorial Lecture to the Royal Meteorological Society in 1927. Other workers have since made much use of this technique. In the 1930's, Sir Geoffrey gave new impetus to the study of turbulence in his now-famous series of papers on the statistical theory of isotropic turbulence. This work is very wide in scope and will find application in meteorology as it has already done in other fields of fluid-motion study. Sir Geoffrey has, of course, also made many outstanding contributions to other branches of physical science.

Elliot Medal of the U.S. National Academy of Sciences: Prof. J. T. Patterson

The Daniel Giraud Elliot Gold Medal of the United States National Academy of Sciences has been awarded to Prof. J. T. Patterson, director of zoological research in the University of Texas. The Elliot Medal is an annual award and is given for an outstanding paper on original research in zoology or palæontology. Prof. Patterson has made important contributions to genetics, particularly by his papers on isolating mechanisms which have been published in the volume entitled "Studies in the Genetics of *Drosophila*: V. Isolating Mechanisms", issued by the University of Texas in 1947. The studies reported in this volume mark the culmination of research in the phylogeny of *Drosophila* by genetical methods which Prof. Patterson initiated at the University of Texas more than twenty-five years ago. As a combination of experimental and taxonomic investigation it represents a highly significant contribution to research on the problem of species.

Sir George Beilby Memorial Fund: Awards for 1950

The administrators of the Sir George Beilby Memorial Fund, representing the Institute of Metals, the Royal Institute of Chemistry and the Society of Chemical Industry, have decided to make two awards for 1950, each of one hundred guineas, from the Fund. These awards have been made to W. A. Baker, in recognition of his experimental contributions to knowledge of the factors determining the production of sound castings of non-ferrous metals and alloys; and Dr. G. Whittingham, in recognition of his experimental contributions to knowledge of the combustion products of fuels containing sulphur and their effects on corrosion. Mr. Baker joined the staff of the Assay Office, Royal Mint, London, as a student assistant and graduated in metallurgy at the University of London as an external student in 1934. Shortly afterwards he joined the British Non-Ferrous Metals Research Association, where he was engaged mainly on such problems as the effects of volume changes and gas evolution in the solidification of metals and alloys, influence of alloy constitution and other metallurgical variables on the casting characteristics of the materials, and the general principles to be observed in developing foundry tech-

niques yielding serviceable castings. Recent work in non-ferrous physical metallurgy has included the equilibria between oxygen and phosphorus in molten copper. Dr. Whittingham is a Cambridge graduate, and in 1942 he joined the British Coal Utilization Research Association and is now the superintendent of the Association's Combustion Department. He has studied particularly the formation of sulphur trioxide during the pre-flame and flame combustion of carbon monoxide, hydrogen and hydrocarbon gases containing small amounts of sulphur dioxide. This work led to a new theory that sulphur trioxide could be formed in combustion processes as a result of a gas-phase reaction between sulphur dioxide and oxygen atoms. His later work has included spectroscopic observations on flames containing sulphur compounds and on the luminescence of burning carbon, and an examination of the effects of fine smoke particles on combustion gases containing sulphur oxides.

Cadman Memorial Medal: Dr. Robert E. Wilson

The Cadman Memorial Medal of the Institute of Petroleum has been awarded to Dr. Robert E. Wilson, chairman of the board of the Standard Oil Co. (Indiana). After the presentation of the Medal on June 21, at the Royal Institution, 21 Albemarle Street, London, W.1, Dr. Wilson will give the third Cadman Memorial Lecture, his subject being "Management and Research in the Petroleum Industry". Dr. Wilson was born in Pennsylvania and is a graduate of the Massachusetts Institute of Technology; he began his career as a research associate at the Institute and later was appointed a director of research there. In 1922 he became assistant director of research at the Whiting Refinery of the Standard Oil Company (Indiana), later becoming a director and vice-president of the Company. He was appointed chairman in 1945. During the Second World War Dr. Wilson was chairman of the Committee on Petroleum Economics of the Petroleum Industry War Council.

Engineer-Captain Edgar C. Smith, O.B.E., R.N. (ret.)

In *Nature* of April 28 and May 19 are articles by Engineer-Captain Edgar C. Smith on memorials to scientific men in Britain. These articles open a series which we hope to publish during the course of the Festival of Britain, and are the latest of his numerous historical contributions to *Nature*, *Engineering*, the *Transactions of the Newcomen Society*, and other periodicals. Capt. Smith has just entered upon his eightieth year, having been born on May 5, 1872, at Newport Pagnell. His boyhood was spent at Gravesend, where his father, George Charles Hooper Smith, kept a school. After a short period at Finsbury Technical College under John Perry and Silvanus Thompson, he devoted some six years to acquiring a varied workshop experience, mainly in the West Country, and then, at the age of twenty-three, joined the Royal Navy as a direct-entry assistant engineer. In the next twenty-seven years he served in the battleships *Trafalgar*, *Sans Pareil*, *Barfleur* and *Magnificent*, the cruisers *Fearless*, *Carnarvon* and *Minerva*, the destroyer *Orwell*, on the staff of the training ship *Britannia*, and in the Royal Dockyards at Hong Kong and Devonport. He retired in 1922, and has since devoted himself to scientific biography and the history of naval engineering, studies which began forty-five years ago when the *Orwell* sustained collision damage that kept her in dock at Leith for several months, thus enabling Engineer Lieutenant Smith (as he then was) to explore the libraries and bookshops of Edinburgh and to collect biographical material, some of which he has deposited in the office of *Nature*. His labours in the field of naval engineering history have been particularly well timed, for he has been the means of recording the personal recollections of many naval engineers whose service dated back to the days when steam was still auxiliary to sail.

Kossuth Awards in Hungary for 1951

Winners of the 1951 Kossuth Awards in Hungary, which are given for outstanding work during the past year, have recently been announced. Fifteen of the Awards are for 20,000 forints and sixty-nine for 10,000 forints, making a total of nearly a million forints (about £30,000). The Awards are divided between four sections on natural sciences, humanities, arts and literature, and social reconstruction, respectively; those for natural sciences are as follows, the value being 10,000 forints except where otherwise stated. *Agricultural Science:* Prof. G. Ubrizsy, for the application of Soviet plant-protection methods and his contribution to the book "Handbook of Practical Plant Protection". *Botany:* Prof. R. Soó, for work in botanical science. *Chemistry:* Prof. E. Schulek (20,000 forints), for research into chlorocyanide compounds, the theory of absorption indicators and methods of gas analysis; L. Erdei, for work on the use of ascorbic acids in chemical analysis. *Geology:* Prof. S. Vitális, for contributions to geological map-making; Prof. A. Földvári, for research into the use of minerals, and the discovery of mineral deposits; Prof. M. Vendel, for work on the classification of ore deposits. *Medicine:* Prof. Ö. Kerpel-Frónius, for research into infantile atrophy and exsiccative toxicosis; Prof. A. Babics, for research into kidney infections. *Mathematics:* Prof. G. Hajos, for work on the study of group principles; Prof. P. Rózsa, for investigations on recursive functions; G. Alexits, for research into orthogonal series analysis. *Physics:* Prof. L. Jánossy, for work on cosmic rays; I. Kovács and A. Budó, jointly, for work on the examination of molecular spectra. *Technology:* J. Kóta, of the Mine Safety Research Institute (20,000 forints), for research into mine explosions; L. Heller, for work on air condensing systems.

Royal Botanic Gardens, Kew: Exhibition

By invitation of the director, Sir Edward Salisbury, 477 members of scientific societies and university students attended at the Herbarium and Library of the Royal Botanic Gardens, Kew, during May 4–5. In the absence of the director through illness, the visitors were welcomed by the keeper, Dr. W. B. Turrill, who briefly outlined the history, organization and work of Kew and summarized the objects of the exhibition that had been staged in the three wings of the Herbarium. A large series of beautifully arranged plants and plant specimens illustrated some of the many lines of research on which members of the Kew staff are engaged. There were also exhibits of plants of special interest to undergraduate students, who had come from most of the English and Welsh universities. Among the subjects fully demonstrated several may be mentioned. Thirty-nine genera of Coniferæ were represented by living plants, and a large series of rhododendrons in flower showed the range of structure in this genus. The vegetation of South Africa, of British Somaliland, of high moun-

tains, of Kangaroo Island (South Australia) and of the Andes indicated the connexions between systematics and ecology, as did also the germination of hundred-year old seeds, a large series of tropical megaphyllous plants and a fine display of dispersal mechanisms in grasses. Diverse evolutionary aspects included a most instructive series of variations of the central theme of a legume, leaf-shape in species and hybrids, variation in species of *Dianthus* and *Tulipa*, the inflorescence of *Carex*, and parallelism in Fungi. The morphological basis of much taxonomy was illustrated with reference to ferns, bladderworts, parasitic flowering plants, *Monadenium*, heteranthy in orchids, the procedure in formal taxonomy, and bad collecting. The importance of anatomical and biochemical aspects of plant taxonomy were demonstrated by reference to *Strophanthus*, wood structure, and the vegetative structure of flowering plants. The taxonomic basis of economic botany was shown with regard to wild cereals of Iraq, fence or barrier plants in warm climates, and the use of seaweeds in industry. Large series of living specimens of plants of special interest attracted much attention. Paintings and drawings showed the importance of the work of the botanical artist. Series of recently published books on several subjects were on view. An unusual exhibit was that of samples of newspapers from all parts of the world that had been used in forwarding plant specimens to Kew.

Classification of the Coli-Aerogenes Bacteria

In 1949 a joint Sub-Committee of the Society for General Microbiology and the Society for Applied Bacteriology issued a report on the term 'coliform' (see *Nature*, **163**, 394; 1949), hitherto used by medical, veterinary, agricultural and water bacteriologists to describe organisms which are of interest to them for different reasons and have thus been classified in different ways. The essence of the report was that the word should not be used as a noun, that it describes organisms resembling *Bacterium coli* morphologically and tinctorially but not necessarily in cultural and biochemical behaviour, and that it should not be used for defining any particular group. Later, the Society for Applied Bacteriology, feeling that it was of great importance that workers should be able to recognize readily organisms described by those working in other fields, set up a sub-committee to examine the methods of classification of non-sporing, Gram-negative rods producing acid and gas from lactose, in the hope that uniformity might be established. Its recommendation is that these organisms, comprising the 'coli-aerogenes' bacteria, should be classified into six basic groups according to their behaviour in the indole, methyl-red, Voges–Proskauer and citrate-utilization tests, and that further subdivision should be based on the temperature at which acid and gas are produced from lactose, and the ability to liquefy gelatin and pectin. The nine species thus recognized are *Bact. coli* types I and II, Intermediate types I and II, *Bact. aerogenes* types I and II, *Bact. coli* type I 44° C. negative, *Bact. cloacæ* and *Bact. carotovorum*. The eight so-called irregular types appearing in earlier classifications have been eliminated. The report (obtainable from the General Secretary, Society of General Microbiology, 35 Villiers Road, Southall, Middlesex), which contains details of the preparation of the culture media and methods of performing the tests, will be welcomed by workers in the relevant fields; but it is recognized that additional tests may be necessary in certain forms of research and that more information is required on some aspects of the problem.

Liquid Metals

The United States Atomic Energy Commission and the Department of the Navy have jointly issued a "Liquid-Metals Handbook" (pp. 188; Washington, D.C.: Govt. Printing Office, 1950; 1.25 dollars) dealing with the uses and properties of the lower melting-point, liquid metals. Although these may be used as ecolants in nuclear chain reactors producing power, they already have, or may in the future have, spheres of utility in very many other directions. The information here collected is therefore of direct interest to the chemist, the engineer, the metallurgist and the physicist. In the first chapter the industrial utilization of liquid metals is considered at length, particularly in connexion with heat-transfer, and uses are mentioned which range from the already established practice of cooling valves in aircraft engines with liquid sodium, to their employment for reheating steam in turbine plant, the pasteurization of milk or in the preheating of the air for blast furnaces. Chapter 2 is concerned with the physical properties of liquid metals with melting points up to that of aluminium, of two sodium–potassium alloys, and of the ternary lead–tin–bismuth eutectic. A large amount of data of value in many branches of science is included. The chemical properties and laboratory techniques, the resistance of materials to attack by liquid metals, heat-transfer and the large-scale handling of such liquids are then discussed. Each section is concluded by a most valuable bibliography. This is a unique and very stimulating publication.

Physical Society: Summer Meeting in Belfast

The Summer Meeting of the Physical Society will be held in the Department of Physics, Queen's University, Belfast, Northern Ireland, during July 5–7, 1951, and is being organized under the auspices of Prof. K. G. Emeléus. It will be divided into three sessions, devoted to (1) textile physics, (2) gas discharges and spectra, and (3) cosmic rays. On July 5 there will be a visit to the Linen Industry Research Association at Lambeg, and on July 7 it is hoped to include a trip to the Giants' Causeway. Application forms, which can be obtained from the offices of the Physical Society, should be returned to Miss J. Thompson, Physics Department, Queen's University, Belfast, Northern Ireland, not later than June 6. Applicants will require passports or travel permits.

Joint Engineering Conference in London

On the occasion this year of the Festival of Britain, a Joint Engineering Conference will be held in London at the Institutions of Civil, Mechanical and Electrical Engineers, during June 4–15, the main purpose of which will be to record the contributions to the advancement of civilization made by engineers and scientific workers in Great Britain during the past hundred years. In addition, it is hoped that distinguished foreign engineers will participate and outline how the contributions from their own countries fit into the general pattern. The interdependence of all branches of engineering and the ever-growing co-operation of the members of the three major engineering Institutions in Great Britain will be emphasized, and the Conference will be open to all members of the three Institutions and to members

of the institutions and societies participating in the Conference of Commonwealth Engineering Institutions and the Conference of the Engineering Societies of Western Europe and the United States of America. Besides formal sessions, there will be a fairly wide choice of excursions and other social functions. The proceedings of the Conference will be published in eleven separate parts, as follows: (1) formal proceedings at the opening and closing sessions, and general summary of the Conference; (2) railways; (3) sea transport; (4) power; (5) aviation; (6) engineering education and practical training; (7) road transport; (8) telecommunications; (9) public health in municipal engineering, water supply and sewerage; (10) gas industry plant, mining and steelworks plant; (11) electrical measurements, television, cables, lighting and mining. Further details can be obtained from the Secretariat of the Conference at the Institution of Civil Engineers, Great George Street, London, S.W.1.

Ray Society: Annual General Meeting

The one hundred and sixth annual general meeting of the Ray Society was held on March 29. Two books, "Tunicata", by Prof. N. J. Berrill, and "British Water Beetles", by Prof. Frank Balfour-Browne, were published and distributed during the past year; it was announced that the first volume of "British Spiders", by G. H. Locket and A. F. Millidge, is about due for distribution, and that "British Mysidacea", by the late Prof. W. M. Tattersall, will follow soon after this. Progress was reported on the volumes "Watsonian Vice-counties", by J. E. Dandy and E. W. B. H. Milne-Redhead, and "British Sponges", by Dr. Maurice Burton. Officers of the Society were elected as follows: *President*, Lieut.-Colonel R. B. Seymour Sewell; *Vice-Presidents*, Dr. John Hutchinson and Dr. Errol White; *Honorary Treasurer*, Lieut.-Colonel W. P. C. Tenison; *Foreign Secretary*, Arthur Exell; *Honorary Secretary*, Dr. Maurice Burton; *New Members of Council*, Dr. W. S. Bristowe, Captain Cyril Diver, Dr. L. Harrison Matthews and N. D. Riley.

Announcements

Dr. J. D. Mounfield, at present head of the research department of the British Arkady Co., Ltd., Manchester, has recently been appointed principal of the National College of Food Technology. Dr. Mounfield, who is a graduate of the University of Manchester, has worked in the past for the British Flour Millers Research Association, and during the Second World War he carried out research for the Ministry of Food into the drying and storage of grain.

Dr. A. L. Rae has been appointed to the newly created chair of sheep husbandry at Massey Agricultural College, Palmerston North, New Zealand. Dr. Rae has recently completed graduate study under Dr. Jay L. Lush at the Iowa State College, United States, followed by a tour of the animal breeding institutions in the United Kingdom. He has concerned himself with sheep breeding problems and especially the statistical treatment of non-numerical data.

The Royal Dutch-Shell Group of oil companies is offering a research studentship in geophysics, of value £400 a year, which is open to men of any nationality less than twenty-seven years of age on October 1. The studentship is tenable at the University of Cambridge, initially for two years, but it may be renewed for a third year. Further details and application forms (to be returned by July 1) can be obtained from B. C. Browne, Department of Geodesy and Geophysics, Downing Place, Cambridge.

The Challenger Society is prepared to consider applications for small grants in aid of research in marine biology or oceanography at a recognized laboratory during the year June 1951–June 1952. Applications, accompanied by details of the proposed research, should reach the honorary secretary, Mr. N. B. Marshall, British Museum (Natural History), London, S.W.7, before the end of May.

A symposium on "Recent Developments and Techniques in the Maintenance of Standards" will be held at the National Physical Laboratory, Teddington, during May 21–22. The standards to be discussed are those of primary loads, length, radioactive isotopes, temperature, luminance and frequency; two formal papers will be given on each of these topics. Invitations to the symposium have been sent to various standards organizations, and the attendance will be fully representative of European and North American countries, as well as several members of the British Commonwealth. The proceedings are to be published in due course.

By the courtesy of His Grace the Duke of Bedford the grounds of Woburn Park, Beds, are to be open to the public during the week May 28–June 2 (11 a.m.–5 p.m.), under the guidance of the Fauna Preservation Society. The Woburn Estate comprises about 4,300 acres of woodland and 17,000 acres of agricultural land. The collection of foreign mammals and birds in Woburn Park was started by the eleventh Duke about the year 1895. Of the species of deer which can be seen, the most interesting is Père David's Deer, which form the only herd in existence, since the animal is now extinct in its native China. Admission charges to the Park will be: adults, 2*s*. 6*d*.; children, 1*s*. Further details can be obtained from the Secretary of the Fauna Preservation Society, c/o Zoological Society of London, Regent's Park, London, N.W.8.

In *Nature* of February 18, 1950 (p. 264), it was stated that the *Chemische Zentralblatt* had been issued in a combined form; the editor, Dr. M. Pflücke, informs us that the journal is published jointly by Akademie-Verlag, Berlin, and Verlag Chemie, Weinheim.

L'Astronomie for January 1951 contains a number of interesting items, the first of which gives a short description of the photography of nebulæ in monochromatic light (Hα), and the cover bears a photograph taken on November 6, 1950, at the Observatory of Haute-Provence. On p. 1 there is a photograph of the instrumental equipment in use at the Observatory. The eighth and last of the series of articles on the construction of an amateur's telescope appears, in which a note of warning is given at the end: while a 20-cm. reflector with accessories may be relatively simple to construct, considerable difficulties may be encountered in attempting to make a 30-cm. telescope. A short description of the appearance of the blue sun and moon, seen in various countries during September 26–28, 1950, is given; but, strange to say, the author professes to be ignorant of the cause of the phenomenon. The explanation is, of course, well known to meteorologists, and the phenomenon is fairly common in countries where a large amount of fine dust is liable to be carried into the upper regions of the atmosphere.

COUNCIL FOR THE PROMOTION OF FIELD STUDIES

3. DALE FORT FIELD CENTRE

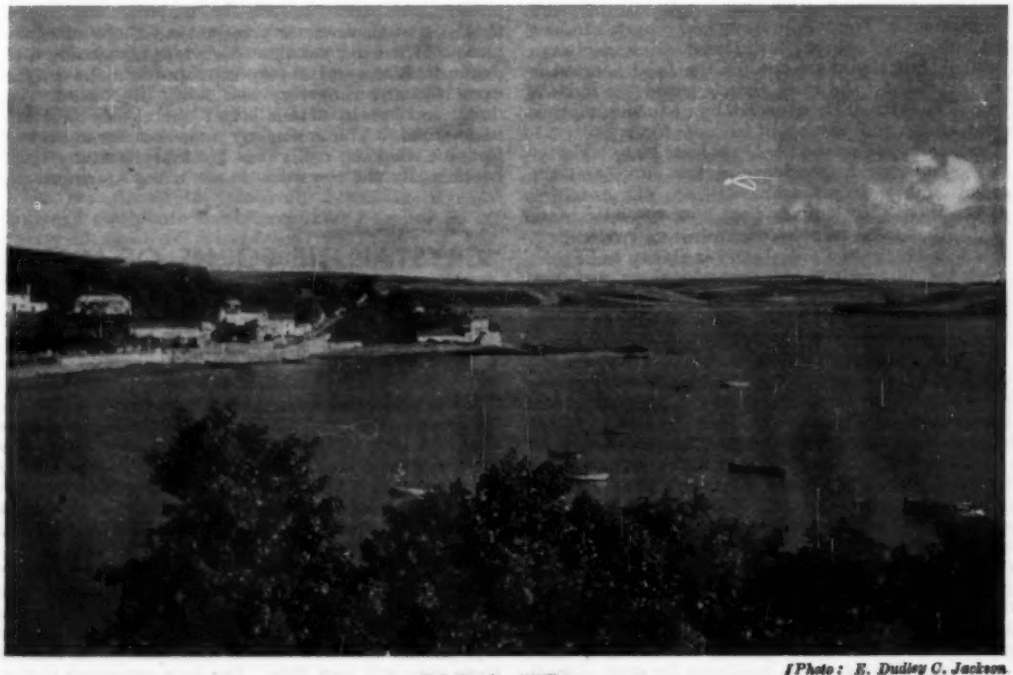
By J. H. BARRETT
Warden

DALE FORT stands on the tip of a promontory overlooking the waters of Milford Haven in Pembrokeshire. When establishing its series of field centres, the Council for the Promotion of Field Studies carefully selected sites in a wide variety of regions. At Dale Fort there are facilities for all those studies based on a coast. Within three miles of the Centre are beaches of every degree of exposure, from sheer cliffs pounded by Atlantic gales, through rocky coves and sheltered bays to the shingle and mud of the flats where the Gann stream goes quietly down to the sea. Inevitably marine biology bulks larger in the life of the Fort than anything else, although the geographical interest of the county presents a challenge to the geographer as clearly as the coastline does to the zoological and botanical research worker. Perhaps the only danger inherent in the superb site of the Fort is that the work of the Centre might tend to become too specialized. While making the most of its local opportunities, the Centre must always welcome workers in any subject, for the Council's scheme includes historians, artists and archæologists as well as zoologists and botanists. No week is more stimulating than when artists, specialist research workers, amateurs and school parties are there together, all doing different things and each contributing some point of view in discussions that is fresh to the others. Any idea that the amateur naturalist is not welcomed would be dismissed if the doubter had once seen how important to a Centre is the enthusiasm of an amateur for his chosen study.

Skokholm Bird Observatory is an integral part of the Centre. For four years an ecological survey has been in progress. An island of only 250 acres has peculiar advantages for this type of research work. The primary botanical maps are complete. Detailed analysis of the composition of certain fresh- and salt-water communities is progressing. Micro-climate stations are maintained. A mass of information on the distribution and population changes of many animals has been accumulated. Research workers will find much background information readily available. Amateur naturalists who visit the Observatory, in numbers, learn how much more interesting their subject becomes as soon as a plan of work is defined and developed. No teaching is organized on the island; this is the responsibility of the main centre at Dale Fort.

More than a thousand students visit each of the Council's field centres every year, a student being defined as anybody wishing to know more of the subject that already interests him. A larger number go to Dale to learn about the intertidal fauna and flora than are accommodated in any other marine station in Britain; they are mostly undergraduates and from school sixth forms.

The unique diversity of animal life on the seashore is well known. The intensity of the struggle



Dale Road and Village

[Photo: E. Dudley C. Jackson

for existence is increased by the hazards of an intertidal life. Many different solutions to the problems have been evolved. The minutely delicate adaptations, the mechanisms of efficiency, the puzzling and beautiful arrangements within a natural community frequently stir students to curiosity and so lead them to the unique pleasures of discovery. Only in a few cases can schools succeed in teaching discrimination. It is a sad result of the present formal educational system that, if left to themselves, most of those from school sixth forms pay more regard to words and diagrams written on a blackboard than to the evidence of their own senses. The marine biology courses at Dale require students to observe critically for themselves, to record accurately and to interpret honestly—and quite incidentally something is learnt that is useful when facing examiners.

The same principles underlie all the courses. Geographers are sent about the peninsula to collect geographical information. Journeys include frequent stops to inspect particular features. The whole week is designed, however, as something more than an unco-ordinated series of simple exercises. The attempt is made to integrate the effects of geology, of meteorology and of man upon the natural scene; to show how man, like any other animal, has adapted himself to his surroundings, and how an unbroken thread of continuity binds the details of the landscape together and so imposes a pattern on the life of man himself. In seeing this for themselves, the sixth formers have suddenly progressed from the uncritical and automatic digestion of facts presented in tidy parcels during 45-minute lessons to an understanding of the real meaning of learning lessons at all. "In understanding is our only emancipation." Hundreds of undergraduates and sixth form students take their first critical look at anything while among the Dale seaweeds or puzzling over some detail in the Pembrokeshire landscape. At Dale there is no formal presentation of factual information. Each student must make the discovery for himself. Help is always available, but the short cut for the faint-hearted is never provided; the more that is asked the more is given. The Council's centres are by no means another patent aid to the passing of examinations.

The small staff at the Centre is kept busy. Forty-five students are in residence at one time, and the warden and assistant warden share the teaching between them. Not only do they have to understand, but also they must be able to transmit understanding. Their scope is limited only by their ability to acquire knowledge in subjects far outside their training. The nature of the work forces them to take a very wide view, with the underlying danger that they may become jacks of all trades and masters of none. A Centre cannot function properly without the assistance of specialists. Any teaching establishment suffers if no research work is in progress within it. The teacher who has ceased to learn has probably also lost his interest in teaching. The Centre's staff is saved from this calamity by all that goes on around them. Whether they want to or not, they must go on finding out things, if only to answer the questions from students who are interested in the zonation of gastropods, cold fronts, microliths or the breeding behaviour of redshanks. Increasing their general knowledge of the region will, for several years, absorb what little time might otherwise have been available for research in their own subject. It is not anticipated that, however skilfully they may be directed, quite inexperienced students in residence for only a week can ever produce results of scientific value. To a great extent it is left to pure research workers who use the Centres to contribute not only their attitude to a problem (which is an important contribution) but also the results to the Centres' store of local knowledge.

The original plans of the Council were that many of the parties visiting its centres would have leaders responsible for the programme of work. Experience at Dale is that very few teachers are prepared to teach their own sixth form in the field the most rudimentary natural history. With their large classes and tight schedules of work to be got through, they in general find it hard to acquire the knowledge that can only be got from looking at Nature in the field. The Centre, in fact, has to teach the teachers, and at Dale special courses are given each year to demonstrate the simple techniques involved. Some training colleges now include in the syllabus a week at Dale as a proper complement to the work done in laboratory and library. The influence of the Centre is spread very widely in this way, and the responsibilities are correspondingly great. Quite apart from the course itself, these various kinds of people gain something from being for a week in a building on the edge of the sea and far from the smoke of chimneys.

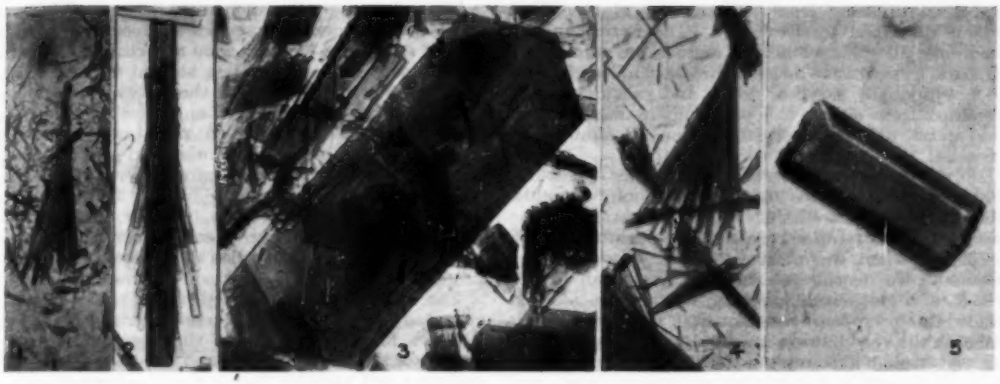
Most of the students are themselves quite strange to rural natural surroundings. Perhaps ten per cent of those still at school have never spent a night away from a town before they come to Dale, and find it difficult to realize that the inhabitants of a remote village are not only content but actually prefer their village to the so-called amenities of the towns. This realization cannot be allowed for on the Centre's programme; but it represents an important part of the work. For seven days students' movements are controlled by tides and not by a watch. They are living amid natural beauty. Slowly they become aware that the whole scene is greater than the sum of its parts. Whenever possible, discussions, teaching and demonstrations at Dale are attempts to shine a light upon the great mystery and unity of Nature. In doing so, certain details stand out clearly and are understood. The schoolboy feels less strange, less lost in what is really his natural habitat; just occasionally the reward is to see a boy transformed.

CRYSTALLINE FORMS OF MYOGLOBIN FROM HORSE HEART

By R. A. LAWRIE

Low Temperature Station for Research in Biochemistry and Biophysics, Cambridge

THE small molecular size of muscle hæmoglobin[1], presumably indicating correspondingly simple structure, makes this protein particularly attractive for analysis by X-ray crystallography[2]. Nevertheless, although myoglobin was first crystallized in 1932 (by dialysis against ammonium sulphate), the only habit reported for some years was that of thin needles, occurring in 'wheat-sheaf' bundles[3]. In 1942, however, crystals of beef myoglobin as minute, triangular 'plates' were obtained from this medium[4]. Although Rees[5] discovered later that large, relatively wide, 'plate'-like crystals could be obtained by permitting crystallization from a concentrated phosphate buffer, these were still very thin. The long exposures to the



Crystals of myoglobin. 1, Ammonium sulphate, 3 days; 2, ammonium sulphate, 6–8 weeks; 3, phosphate buffer, 36 hr.; 4, phosphate buffer, 12 hr.; 5, phosphate buffer, 4 weeks. 1–4, × *c.* 100; 5, × *c.* 170

X-ray beam which were consequently necessary to secure a reasonable diffraction photograph appeared to damage them and limited the inform tion they provided[3]. It has thus been of interest to study the various crystalline habits of the protein and to attempt the production of crystals in which thickness is of the same order as length and breadth. Some findings in the course of this work are presented here.

Myoglobin (with residual hæmoglobin) was isolated from horse heart by the method of Theorell[3,4], as a clear, deep-red solution. Ammonium sulphate was added to saturation, causing precipitation of mixed amorphous myoglobin and hæmoglobin. This process was permitted to continue for not longer than two hours, at 0° C., after which the precipitated pigments were swiftly separated off by suction filtration. (Prolonged standing in contact with ammonium sulphate, at this stage, produces a microcrystalline material which is difficult to re-dissolve.) The brown solid was transferred to a mortar, in an ice-bath, and extracted by 4*M* phosphate buffer (*p*H 6·8 : 312 gm. $NaH_2PO_4.2H_2O$ + 348 gm. K_2HPO_4 per litre). The extraction was carried out at 0° C. to minimize denaturation and to aid solubility, myoglobin being less soluble at room temperature. Hæmoglobin, unlike myoglobin, is practically insoluble in concentrated phosphate buffer[3], and may be removed by gravity filtration of the extract. Saturation of the latter with ammonium sulphate (after dialysis against distilled water, in the cold, until freed from phosphate) produced an amorphous precipitate, consisting, almost entirely, of brown metmyoglobin. From this point, procedure depends on the type of crystal desired.

(*a*) *Crystallization from Ammonium Sulphate.* The 'wheat-sheaf' aggregates of needles (see Fig. 1), which seem to be frequently associated[2–4] with myoglobin crystallized from this medium, may readily be produced by dissolving solid metmyoglobin, prepared as above, in a minimal quantity of distilled water and adding ammonium sulphate to about 4*M* concentration. The solution is left at room temperature (18° C.) for two to three days. Prolongation of the time of crystallization, by making the initial water solution of the pigment more dilute, and keeping the material at 0° C., after addition of ammonium sulphate to 4*M* concentration, results in the formation of large rosettes of needles, having an overall diameter of about 5 mm.

Both plate and prism forms of crystal were also obtained from this medium. A solution of metmyoglobin in water was reduced with sodium hydrosulphite, and a stream of carbon monoxide passed through. The resulting carbon monoxide – myoglobin solution was dialysed against saturated ammonium sulphate in an atmosphere of carbon monoxide for three days at 0° C. Insoluble debris was centrifuged off and the clear solution set aside for three to four weeks at 0° C., when 'plate' crystals of carbon monoxide – myoglobin were obtained. These appeared in the form of regular hexagons, but their true habit has not as yet been confirmed. (Keilin and Schmid have reported similar crystals from whale myoglobin[5].) These crystals were kept for a further three to four weeks at 0° C., transforming into prisms of considerable thickness; these occurred in clusters, however (Fig. 2).

(*b*) *Crystallization from Phosphate Buffer.* Typical plate-crystals, in the form of irregular hexagons, such as those described by Rees[6], are easily obtained by saturating a quantity of 4*M* phosphate buffer, at 0° C., with freshly precipitated, amorphous metmyoglobin: insoluble material is filtered off, one-third of its volume of distilled water is added, and the solution is left at 0° C. for one to two days (Fig. 3). When a buffer of *p*H 6·2–6·4 was employed, the plates obtained were rectangular, some individuals having an 'incomplete' corner, not unlike the crystal of cholesterol. If, however, crystallization from the phosphate medium is speeded up by allowing a saturated (0° C.) solution of metmyoglobin in 4*M* phosphate to stand at room temperature, there appear, in 12 hr., sheaves and rosettes of needles, exactly corresponding to those obtained from ammonium sulphate after two days (Fig. 4). On the other hand, just as prolongation of crystallization time from ammonium sulphate eventually yielded crystals having an appreciable depth, so, too, crystallization from phosphate buffer, after four weeks, produced 'solid' forms. This occurred, on several occasions, merely by keeping the plate-form crystals at 0° C.

At other times, and also at 0° C., when the initial concentrated solution of metmyoglobin was kept absolutely still, on a shock-absorbent mat, 'solid' crystals appeared without the previous production of the plate form. These crystals grew as separate cuboids, exhibiting no tendency to aggregate (Fig. 5),

and thus differing from the sheaves of elongated prisms described by Drabkin[9]. The nature of the medium—phosphate buffer or ammonium sulphate—appears, therefore, to be less critical than has hitherto been supposed; needles, plates and prisms may be obtained from either, the predominant factor being the speed at which crystallization is allowed to proceed.

It was desirable to standardize the conditions yielding 'solid' forms of metmyoglobin crystals. Moreover, it appeared that slight fluctuations in the environmental temperature were responsible on the occasions when the most satisfactory prisms were secured. To accentuate this effect, a small hollow vessel, of high thermal capacity, was constructed and placed in a room kept constant at 0° C. Heating coils beneath the vessel were connected to mains electricity supply through a mercury switch, the latter controlled by a clockwork motor driving an eccentric cam, and so arranged that the circuit was complete or broken for periods of 13 hr. alternately. The apparatus was adjusted to give a repetitive variation in temperature from 0° C. to 20° C. It has been found that solutions of freshly prepared and precipitated metmyoglobin, in 3*M* phosphate (*p*H 6·8: 234 gm. $NaH_2PO_4.2H_2O$ + 261 gm. K_2HPO_4 per litre), of concentration 5–10 mgm. metmyoglobin per ml., if kept absolutely free from vibration within the vessel described, will produce a cuboidal (or rhomboidal) prism habit of crystal in three to four weeks. Concentrations greater or less than those in the range given are apparently not so satisfactory, under the conditions described, for producing 'solid' forms. From the points of view of shape, and of the absence of aggregation, such crystals are suitable for X-ray analysis, but they are inclined to be small. Further work, designed to increase their size, is continuing.

I wish to thank Prof. D. Keilin for his advice and encouragement. I am also grateful to Mr. D. P. Gatherum, of the Low Temperature Research Station, for the photomicrography and to Mr. A. Snow for constructing the crystallization vessel.

This work was carried out as part of the joint programme of the Food Investigation Organization of the Department of Scientific and Industrial Research, and of the Scientific Adviser's Division, Ministry of Food. [Dec. 8.

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RADIO OBSERVATIONS OF THE AURORA ON NOVEMBER 19, 1949

By N. C. GERSON

Geophysical Research Directorate, AF Cambridge Research Laboratories, Cambridge 39, Massachusetts

A PHENOMENON long known to the radio amateurs was observed on November 19, 1949, over the north-central and north-east portions of the United States and over the adjacent regions of the Dominion of Canada.

This phenomenon, which may be termed 'auroral interaction', generally describes the reception of radio signals at a given location from a northerly direction, even though the transmitting station may lie to the east, west or even south of the receiver. In many instances, the transmitting and receiving stations which are able to establish radio communication through auroral interaction are located geographically so that they cannot communicate with each other during normal ionospheric conditions. During periods when visible aurora is present, however, these stations may establish contact with each other by means of auroral interaction only when the directional antennæ at both locations are directed 'northwards'.

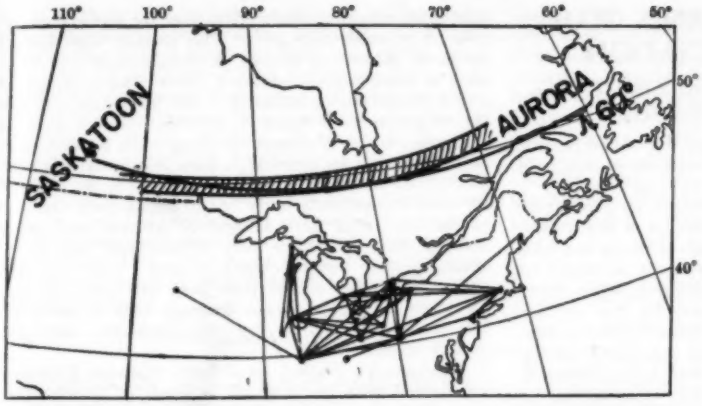
The radio signals received when the waves are returned from the north are characterized by several distinct features. Usually the received signal is modulated both markedly and rapidly. Also, the constant and variable fading which accompanies this type of radio contact is sufficient to discourage the use of radiotelephone during the period when communication is possible. Thus, to maintain (auroral) radio contact between the two stations concerned, it is often necessary to employ continuous wave transmission. In any event, either when utilizing radiotelephone or continuous wave emissions, the received signal has a characteristic flutter and tone which seems to be typical of auroral interaction.

Through an examination of reports of auroral interaction, it seems possible to describe the existence and the spatial extent of a polar aurora even during periods when the sky is obscured. An example of the method is described below. These data were obtained during the period 2355 Greenwich Mean Time, November 19, 1949, to 0145 G.M.T., November 20, 1949. In this time interval, more than fifty-two reports of auroral interaction were made by thirty-seven radio amateurs in twenty-one different localities in the United States and the Dominion of Canada. The operating frequency at which the radio contact was established was about 50 Mc./s. The observational material is plotted in the accompanying diagram, where each line connects the location of the two amateur stations which established communication by means of auroral interaction.

In analysing the observations, it was assumed that the portion of an aurora which has the greatest light intensity was also that portion which allowed auroral interaction to take place. By far the most commonly found altitudes of the lower 'edge' of the aurora borealis is 100 km.[1], and the maximum light intensity in the case of arcs, draperies and drapery-shaped arcs is 5–10 km. above the lower edge[2,3]. Thus, the region causing auroral interaction was considered to lie in the altitude range 100–110 km. above the earth's surface. Under these conditions, it becomes possible to delineate the geographical extent of the auroral projection.

With an altitude range of 100–110 km. as the auroral reflexion region, the extreme southern border of the aurora is limited to a distance of about 1,150 km. from the southernmost stations. This distance allows the tangent ray from the southernmost transmitter to be returned from the aurora. As some stations in radio contact with the most southerly station were located several hundred kilometres to the north, it may be concluded that the angle between the auroral reflexion surface and the tangent ray was acute.

In reducing the observations, ray paths were drawn to a reflecting surface lying just within the tangent



ray distance (of about 1,150 km.). The first results examined were those involving the most southerly stations. The position of the synthesized aurora obtained by this procedure is shown in the diagram. It is unfortunate that no information is immediately available regarding the presence of visual aurora over the eastern part of Canada. However, a report from Saskatoon, Saskatchewan, indicated that an aurora was observed "through the clouds" some time during the period when auroral interaction occurred.

The large degree of modulation in the returned radio signal may perhaps be attributed to two causes : (*a*) a variation in the ability of the ionized particles (either the bombarding particles or those produced by the bombarding particles) to reflect probing electromagnetic rays ; and (*b*) a variation in the absorption properties of the atmospheric regions concerned, this absorption being brought about by energy transferred from the bombarding particles.

Case (*a*) would arise if the density of the charged particles in the reflecting volume changed with time. The simplest explanation would merely require that the charged particles passing through the reflexion volume should arrive in bursts or bunches, where the density of particles changed from burst to burst. If the reflexion arises directly from the protons passing through this common 'beam volume' in varying numbers, the number density in the proton flow would be about 5×10^{10}/cm.[3]. On the other hand, the reflexion may arise from electrons, which would require a minimum number density of about 3×10^{7}/cm.[3]. It seems unlikely, however, that electrons of about 15 eV. energy could penetrate to this depth in the atmosphere. If reflexion occurs from electrons, it would appear more probable that the electrons were formed in the atmosphere by the bombarding particles. (In this event, terrestrial mechanisms for producing the bunching may be considered.) The rapid fading and flutter noted on the reflected signals would be expected to be most pronounced on frequencies close to the critical or penetration frequency ; these are most sensitive to changes in the density of the charged particles causing reflexions.

With respect to case (*b*), it seems clear that if the velocity of the bombarding particles is reduced to zero, a good proportion of the kinetic energy of the particles will be dissipated as heat. The resulting rise in temperature of the atmospheric particles may then be sufficient to produce a noticeable absorption effect.

If it is assumed that the incoming particles, having a velocity of about 3×10^{8} cm./sec., are protons, and if 10^{11} protons are absorbed per second in the altitude range 100–110 km. (where the average atmospheric number density is about 10^{13}/cm.[3]), the average increase in temperature per particle is only about 2–3° K./sec. Of course, high-density bursts of short duration may raise this figure appreciably over short intervals of time. In general, however, it would seem that the heating effect (which may be somewhat high over a small volume) would be dissipated rapidly by means of the general winds and turbulence existing near the 100-km. level. While the time variation in radio wave absorption is undoubtedly inherent in the observed 'garbling', it appears probable that individual bursts of absorption would be smoothed into a general rise in the absorption properties of the atmosphere. Thus, it would also appear that the main effect in producing the rapid variation or flutter of the returned radio waves would arise from (*a*) the rapid variation in number density of the incoming particles, rather than from (*b*) the variation in absorption which these particles produce in the atmosphere.

The procedure described above suffers from several limitations. First, as in any co-operative venture, it cannot be stated with certainty that all possible reports of auroral interaction have been either observed or reported. Undoubtedly, there were a sufficient number of radio amateurs 'on the air' (at localities to the south of those indicated in the diagram) to have utilized auroral interaction in establishing radio contact with other stations had it been possible to do so. However, no reports have been received indicating that an unsuccessful attempt had been made to establish radio contact through auroral interaction. Secondly, the assumption that the aurora is located just within the tangent ray distance from the southernmost reporting stations is open to some doubt.

It is interesting to note that the basic technique underlying this study of the aurora may be refined considerably so as to provide a new tool for auroral observations. The experimental method may be employed for the detection of the aurora when visual observations are difficult because of bright moonlight, scattered light or general cloudiness. The antenna beam-width employed by the amateurs is about 30–35°, making it difficult to determine accurately the azimuth of any particular radio ray received from the aurora ; however, narrower beam-widths undoubtedly could be employed to provide much greater accuracies. It would also be expected that analyses of the rates and character of the garbling and fading of the returned signals would provide valuable information on the mass and velocities of the bombarding particles. [Dec. 19.

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BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

ANNUAL GENERAL MEETING AND THIRD RESEARCH PANEL MEETING

THE second annual general meeting of the British Gelatine and Glue Research Association was held at the Waldorf Hotel, London, W.C.1, on February 7. The director of research, A. G. Ward, in presenting the Council's report*, gave an account of the organization which had been established. During the past year the laboratory premises have been acquired at 2/4 Dalmeny Avenue, Holloway, London, N.7; these premises were previously occupied by the British Food Manufacturing Industries' Research Association, and they have been adapted and equipped to the needs of the British Gelatine and Glue Research Association. There are now separate laboratories for general chemistry, bacteriology, chromatography, physical chemistry, physics, constant-temperature work, and technical work, together with three rooms for balances, autoclaving and stores, respectively; in addition, there are the usual technicians' workshops, reading room and library, and clerical offices. The staff consists at present of one senior research officer and three officers, who with the director of research will carry out the programme of fundamental research, and one senior research officer has been appointed to look after the more technical work. A bacteriologist, who will also undertake independent work, an instrument mechanic, research assistants and secretarial staff bring the total number to fourteen.

The immediate objective of the research programme is the study of the structure and physical properties of gelatine. Being the product of the degradation of collagen, gelatine is not a homogeneous substance, and it is necessary in determining its structure to measure the distribution of molecular weights and sizes, as well as the chemical composition; the nature of the degradation process is also a problem of importance. This, then, is the fundamental research that is being undertaken in conjunction with the short-term work, which is mainly of a practical and empirical nature. In addition, the Association has been issuing two quarterly publications: the first, the "Bulletin", reports on activities of the Association and the industry, and is a medium for publishing small items of research; the other, "Abstracts", reviews all relevant literature relating to the gelatine and glue industry.

The third research panel meeting of the Association was held at Beale's Restaurant, Holloway Road, London, N.7, on February 8. In addition to representatives of member firms, there were numerous visitors, including Prof. F. J. W. Roughton and B. G. McLellan, and representatives of government laboratories and of other research associations. Members of three of the research panels of the British Food Manufacturing Industries' Research Association were also present. The chair was taken by the chairman of the British Gelatine and Glue Research Association, S. G. Hudson.

The first two meetings of the panel having been devoted to the consideration of the raw materials of gelatine and glue manufacture and the properties and methods of study of these substances, the papers at this third meeting dealt with various aspects of the uses of gelatine and glue. The session was opened by E. H. Moore, of Messrs. A. Adams and Co., Ltd., with a contribution entitled "The Use of Gelatine and Animal Glue in Industry". Mr. Moore emphasized the importance of research into the uses of gelatine and glue, to be undertaken along with fundamental research so as to provide a balanced programme of work. In addition, more is required to be done to see that the existing body of information on the uses of gelatine and glue is widely known and used. Animal glues still have very widespread uses in, for example, the wood-working trades; but vigorous action is needed to see that they are not displaced by other materials, either through lack of publicity by the industry or by unnecessarily stringent specifications.

The second paper, on "Some Special Problems Connected with the Use of Gelatine in Foodstuffs", was given by J. W. Selby, of the British Food Manufacturing Industries' Research Association. The food manufacturing industries use some 7,500 tons of gelatine annually, and its simpler analytical characteristics are now defined by law. The statutory instrument specifies upper limits for ash content, arsenic, heavy metals, etc., based on the assumption that gelatine seldom constitutes more than ten per cent of an article of food. There is, however, the possibility that more stringent limits might be applied, and might be extended to include standards of bacteriological purity. Turning to the physical properties of gelatine, Mr. Selby stressed the great importance of high jelly strength. It is also desirable that jelly strength should change as little as possible with the temperature of measurement. Similarly, in many applications the melting and setting characteristics are important, but viscosity of solutions plays only a minor part. Tendency to foam is a disadvantage in most applications.

Mr. G. F. Glover, of the Wiggins Teape Group Research Organization, gave the last paper of the morning session, "Paper Sizing". Tub sizing is performed by running the paper through a bath of gelatine or glue solution before drying. Its function is either to provide an ink-resistant surface and improve the surface resistance to abrasion, or to increase the dry or wet strength of the paper. To secure application mainly in the surface layers, a solution of fairly high viscosity is needed. This is frequently obtained by using a medium-viscosity gelatine or glue with the addition of alum. Temperature control is also important. When penetration through the paper is required in order to modify the bulk properties, higher temperatures, lower viscosities and more prolonged immersion are used. It is common practice to prepare one week's supply of sizing solution at a time. This involves degradation problems, although bacterial attack is effectively prevented by suitable preservatives.

In the afternoon, R. C. M. Smith, of Messrs. Ilford, Ltd., read a paper on "Some Aspects of the Use of Gelatine in the Photographic Industry". Gelatine is unique in possessing a combination of properties which makes it suitable as a medium for the preparation of light-sensitive silver halide dispersions. Its suspending power is one of the most important properties. In this connexion, Mr. Smith mentioned the work of Sheppard and his colleagues on the adsorption of gelatine to silver bromide. The sol–gel transformation plays a great part in making possible some of the manipulations necessary in the prepara-

* British Gelatine and Glue Research Association. Second Annual Report for the Year October 1949 to September 1950 (from the Registered Office at Sardinia House, 52 Lincoln's Inn Fields, London, W.C.2).

tion of modern film, and its mechanism is important to photographic manufacturers. Processing and some stages of the manufacture are only possible because of the ease of diffusion of ions and molecules in the medium into and out of gelatine. For special purposes, it is sometimes necessary either to harden or even insolubilize the gelatine, or to soften it, and gelatine can easily be modified in these ways. Gelatine has a profound effect on the sensitivity of the emulsions, and much work has been carried out on this; but the mechanism of the action is still not completely understood. It is desirable that the gelatine should be of uniform standard from batch to batch, particularly with respect to viscosity and sensitizing power.

CAUSATION AND EXPLANATION IN THEORETICAL BIOLOGY

IN a recent issue of the *British Journal for the Philosophy of Science* (1, No. 4; February 1951), J. S. Wilkie considers some of the classical problems of explanation in biology in the light of a relative theory of causation. A cause is taken to be some factor to which is attributed the disturbance of some regularity. Living things are extremely complex systems in which the parts have causal relations *inter se*: the regular rhythm of the heart is disturbed by nervous stimulation; the regularity of an undifferentiated field of competent ectoderm is disturbed by the presence of an optic vesicle near some part of the field. But living things as relatively isolated systems can themselves be considered as complex regularities which are disturbed by environmental interference. Reaction with the environment can be considered as constituting a causal event only if there is some assignable disturbance of some regularity of the system: since the system is not totally isolated, it will have regular and constant relations with its environment which are necessary to its maintenance as a system; thus the entry of oxygen into the system cannot as such be considered as a causal relation with the environment. On the other hand, episodic changes such as a temporary increase or diminution of oxygen in the immediate environment definitely disturb the rhythms of the organism and can thus be considered as causal. Among such episodic causal events are the reactions of environmental changes with the sense-organs.

Whatever can be deduced from the known properties of the system alone receives explanation, but not causal explanation.

Mnemic phenomena introduce causal events of peculiar interest. With respect to the organism they are causal, since there is nothing in the structure of the organism from which we can deduce the memories it acquires. Whereas in reflex activity the organism behaves as an elastic system, in memorizing it behaves as an inelastic system. Mnemic traces, considered as imposed upon the structure common to a species, are consequences of causal events and therefore causal themselves with respect to the specific regularity of the species. But mnemic traces do not remain indifferent to one another, as do the traces left in the wood of a tree by wet and dry seasons; they become organized *inter se*. Thus the behaviour of these traces has its own regularities which, since they are regularities, might be explained by a knowledge of the properties of the materials of the system (as cleavage patterns can be explained by molecular forces). This, however, appears improbable, since the physical language lacks the necessary concepts (constructs) under which the peculiar behaviour of mnemic traces could be subsumed. Physical attractions all appear as functions of space and time, whereas mnemic attractions appear as functions of space, time and similarity.

Wilkie also attempts to justify teleological explanations; but it is not considered appropriate to treat these as causal explanations.

FORESTRY COMMISSION

ANNUAL REPORT FOR 1949

THE thirtieth annual report of the Forestry Commissioners covering the year ending September 30, 1949, has recently been published*. Since the passing of the Forestry Bill in 1919, the Commission has published quinquennial reviews of the work done, in 1924, 1929 and 1934. The Second World War brought the gap to fifteen years, the present report being the first to be issued since the War ended.

In the thirty years of its existence the Forestry Commission has acquired an area of 1,500,000 acres, of which 971,000 were classified at the time of acquisition as plantable. In addition, 57,000 acres of standing woodland have been acquired. By the aid of planting grants, private owners planted 182,000 acres. Planting operations were of necessity severely interrupted during the Second World War.

With regard to the plantations, which range from 1 to 30 years in age, there is a total of 550,624 acres, of which 515,666 are conifers and 34,958 hardwood trees. The youngest ones, 1–5 years old, cover the largest area (123,483 acres), while the oldest, 26–30 years, the smallest (32,959 acres). These latter are now producing some revenue. Furthermore, there is what the Commissioners term a by-product, namely, the establishment at a small cost of six national forest parks comprising 240,000 acres.

Other minor Forestry Acts have been passed since 1919: the Act (Transfer of Woods) of 1923, which empowered the transfer of the majority of the existing Crown woods—for example, the New Forest, Forest of Dean—to the Commission, and in 1927 a short Act authorizing an increase in the number of Commissioners and empowering them to make by-laws with respect to their properties. The issue in 1943 of a report by the Commissioners on post-war forest policy resulted in the Forestry Act of 1945. The Act brought into force ministerial responsibility for future forest policy, an action which was by then very justifiable. The Minister for Agriculture and Fisheries was responsible for England and Wales, while Scotland came under the Secretary of State, the lands acquired since 1919 being invested under the appropriate Minister.

A further measure of the Forestry Act of 1947 provided for the dedication of private woodland to forestry purposes, and dealt with such matters as the enforcement of dedication covenants in England and Wales and of dedication agreements in Scotland. This measure proved very contentious, and has been subject to considerable modifications.

Lastly, a New Forest Act, 1949, was passed just after the period of this report. The Act amends the

* Forestry Commission. Thirtieth Annual Report of the Forestry Commissioners for the Year ending September 30th, 1949. Pp. 148+15 plates. (London: H.M. Stationery Office, 1950.) 4s. net.

contribution of the verderers and gives them certain additional powers. Provision was also made to enable the verderers to authorize the enclosure of additional land up to a maximum of five thousand acres, for the purpose of growing timber, and the enclosure of a maximum of three thousand acres for cultivation and improvement of grazing. The long-standing problem of the ancient and ornamental woods was met by providing that the verderers may authorize the Commissioners, subject to certain conditions, to make enclosures, individually not exceeding twenty acres in area, for the rehabilitation of these woods.

RADIO-WAVE PROPAGATION AT VERY HIGH FREQUENCIES

THE radio communication engineer is continually seeking opportunities of using the shorter wavelength portions of the radio spectrum for services and applications of various types. Reference was made recently in *Nature* (April 21, p. 617) to the fact that the report of the Beveridge Committee on broadcasting in Great Britain directed attention to the need for actively developing the use of frequencies above 30 Mc./s. (wave-lengths shorter than 10 m.) in order to relieve the congestion in Europe in the medium- and long-wave bands, and to provide a greater diversity in the broadcasting programmes available in Great Britain. The present British television service is being developed in the frequency range 41–68 Mc./s., while a band of frequencies in the region of 90 Mc./s. is available for the development of sound broadcasting.

It was thus very timely that, at a meeting of the Radio Section of the Institution of Electrical Engineers held on April 11, three papers were read describing the results of recent investigations on the propagation of waves at certain very high frequencies. The first of these, entitled "A V.H.F. Field-Strength Survey on 90 Mc./s.", by H. L. Kirke, R. A. Rowden and G. I. Ross, describes measurements made by staff of the British Broadcasting Corporation on the radiation from an experimental transmitter at Wrotham in Kent. Automatic field-strength recording equipment was installed in a vehicle which cruised at a speed of about 1 m.p.h. over a distance of from 50 to 500 yd. in the neighbourhood of each point selected for observation. In this manner measurements were made in various directions from the transmitter up to distances of some 60 miles, which includes the whole of the London area and a considerable portion of south-east England.

It was found that, while the field-strength varied markedly with small changes in position in a built-up area or along a tree-lined road, useful and consistent results could be obtained from the averages of the recorded readings. Thus, it was shown that buildings of normal height in London reduce the average received field by 10–12 db.; but the average for one street may be taken as the average for the district to an accuracy of about $\pm$ 4 db. The variation of field-strength along the street is less with horizontal than with vertical polarization. In hilly country, the minimum field-strength occurred on the near-side slope of a valley and not at the lowest point. On rising ground facing the transmitter, horizontally polarized waves gave stronger fields than vertical polarization; but, when once the peak of the hill has been passed, there is a range on the far-side slope in which vertically polarized radiation gives the stronger field, a fact which confirms the results of previous investigators. From all the results obtained in this work a predicted field-strength contour map has been prepared and is included in the paper. This map refers to the power (25 kW.) and aerial height (500 ft.) of a B.B.C. transmitting station now in experimental use at Wrotham. This investigation has shown that when the Wrotham station is brought into full operation, it is likely to gave a satisfactory broadcasting service, defined by a field-strength of 2 mV./m. or more, to Greater London and most of south-east England.

The other two papers read at the meeting were under the common title of "The Propagation of Metre Radio Waves beyond the Normal Horizon" and describe some theoretical and experimental investigations carried out during the past few years by staff of the Radio Division of the National Physical Laboratory. In Part 1, Dr. J. A. Saxton considers the propagation of very-high-frequency waves over land, and discusses the relative importance of changes in atmospheric refraction near the surface of the earth and the reflexion of waves from high-level inversion layers. Using information on typical atmospheric conditions at various heights, obtained from the usual meteorological charts, the author presents some useful sets of graphs showing the field-strength to be expected at various distances up to 400 km. (250 miles) from the transmitter. The comparative influence on the received field of the three main factors—simple atmospheric refraction, guiding of the waves in a low-level duct, and reflexion from inversion layers—is well illustrated by these graphs. Consideration is also given to the effects of scattering of radio energy by turbulent eddies in the atmosphere; but, except at distances exceeding about 250 km., it appears that such scattering is of less importance than the effect of the mechanisms of abnormal refraction, which may be deemed to include reflexion at elevated inversion layers.

The third paper, forming Part 2 of the joint contribution, is entitled "Experimental Investigations at Frequencies of 90 and 45 Mc./s.", by Dr. J. A. Saxton, G. W. Luscombe and G. H. Bazzard. This describes the results of measurements of the field-strength on these frequencies over distances such that direct transmission from the sender to the receiver was impossible. Two paths, of lengths 110 and 270 km., have been investigated on 90 Mc./s., and one of 160 km. at 45 Mc./s. The recorded field-strengths varied over a range of some 40 db., and there is some indication of a diurnal variation. The statistical distribution of quasi-peak field-strengths as a function of time has been determined, and it is shown that values of field considerably in excess of those corresponding to standard atmospheric refraction often occur. An attempt is made in the paper to interpret the observed field-strengths in terms of the meteorological data obtained from the routine radio sounding-balloon ascents made in Great Britain, and some degree of correlation has been obtained. The results of such investigations are of considerable importance in planning radio communication services for operation over distances well in excess of the normal optical range, and also in enabling an assessment to be made of the extent of any mutual interference likely to be experienced between broadcasting and other services operating in the same frequency channel.

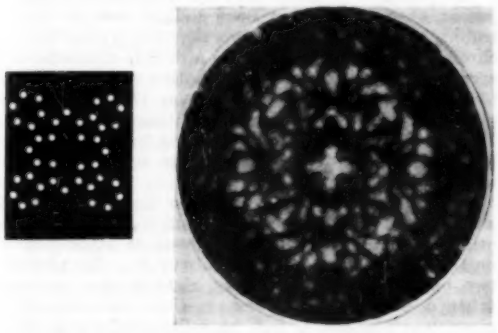
LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Optical Methods in Crystal-Structure Determination

DURING the war years, Sir Lawrence Bragg put forward several interesting suggestions for the application of the principles of physical optics to crystal-structure determination[1,2]. These methods seem to us to be of particular importance at the present time in order both to ease the burden of calculation which has enveloped the subject and also to introduce new *experimental* methods of tackling the initial stages of a structure investigation.

The methods suggested by Bragg were two-fold: first, the summation of Fourier series by optical interference[1], and, secondly, the use of optically derived Fourier transforms[2]. The first suggestion has been developed with some success by Buerger[3,4], and we are also hoping to make use of it on somewhat different lines; but the second method seems at present to be more fruitful, and the present communication is intended to give a brief account of the principle, with an illustration of its beauty and the rapidity with which it leads to results.



(a) (b)

Fig. 1. (a) Mask representing molecule of phthalocyanine in plan. (b) Optical diffraction pattern of this mask

The apparatus used is essentially similar to the X-ray microscope described by Bragg[1]; however, in view of the use of instruments which may now be described accurately as X-ray microscopes[5], we prefer to re-name our instrument the 'diffraction spectrometer', since this emphasizes its main purpose, namely, the observation of diffraction patterns of relatively large-scale objects. A description of the instrument is contained in a paper to be published in *Acta Crystallographica*[6].

Phthalocyanine[7] affords almost an ideal illustration of the method. A model of the molecule, which is known to be planar, is prepared as a mask of holes punched in black cardboard; the mask used is shown full size in Fig. 1,*a*. Its diffraction pattern is shown with a magnification of about 20 in Fig. 1,*b*. The variations in intensity of this optical diffraction pattern are equivalent to the variations in scattering

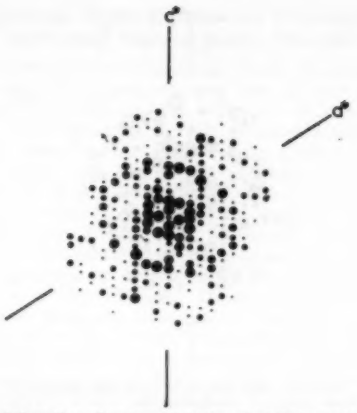
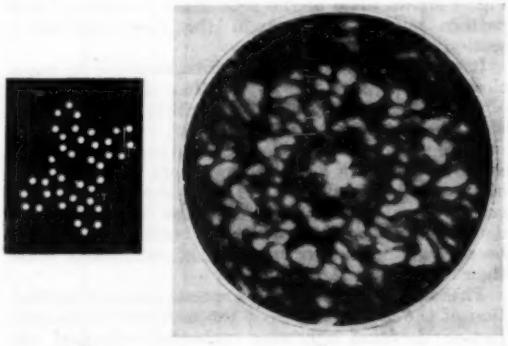


Fig. 2. Half section of reciprocal lattice of phthalocyanine; the intensities correspond roughly to the areas of the spots

of X-rays from a single molecule, and the pattern is, in fact, a representation of Knott's molecular scattering factor[8]. In crystals, we have to deal with a large number of molecules periodically repeated, and the effect of this repetition is to cause the scattered X-rays to be reinforced in specific directions only; in these directions the energy scattered is much greater than that scattered by a single molecule; but we have to pay a heavy price for this advantage, in that in other directions no appreciable amount of energy is scattered at all.

The directions in which X-rays are scattered by the crystal are represented by the reciprocal-lattice points, and if these points are weighted with quantities proportional to the intensities of the corresponding X-ray reflexions, we have a complete representation of the data from which the crystal structure has to be worked out. From the optical point of view, the derivation of a crystal structure is the process of fitting the weighted reciprocal lattice on the diffraction pattern of the single unit so that complete correspondence of weak and strong points in the two is obtained. In practice, of course, the operation can be carried out only in two dimensions, and consequently only one section of the reciprocal lattice can be considered at a time.

Another difficulty also exists: crystals do not contain only one molecule in each unit cell, and thus



(a) (b)

Fig. 3. (a) Mask representing projection of molecule in the orientation deduced. (b) Optical diffraction pattern of this mask

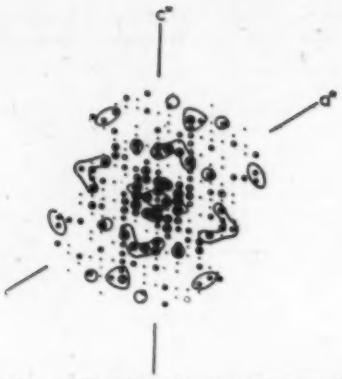


Fig. 4. As Fig. 2, with outline of prominent features of Fig. 3,*b* superimposed

we have normally to consider two or more symmetrically related molecules as a single diffracting unit. This difficulty, however, does not exist for the (010) projection of phthalocyanine, since the two molecules have similar projections separated by $a/2$, and thus the unit cell of the projection is effectively only half the size of the true unit cell.

Fig. 2 is a representation of the $h0l$ section of the reciprocal lattice, the observed intensities corresponding roughly to the areas of the spots; the origin is represented by an open circle. It is not difficult to see the general correspondence between Fig. 2 and Fig. 1,*b*; there is a grouping of strong intensities around the origin, then a gap containing only weak intensities, and then a ring of stronger intensities corresponding with the approximately square-shaped pattern in Fig. 1,*b*. The correspondence, however, is not perfect, because the molecule does not lie in the (010) plane; some rotation from this plane is required, and this will have the effect of elongating the diffraction pattern in a direction perpendicular to the line about which the molecule is rotated. The roughly symmetrical nature of Fig. 2 (which can be best seen by partly closing the eyes) suggests that the molecule is rotated about one of its axes of symmetry, and that this axis of rotation is approximately equidistant from a^* and c^*.

The required tilt can be roughly deduced from the elliptical ring of stronger spots in Fig. 2; and Fig. 3,*a* shows a new mask made to correspond to the tilted molecule. Fig. 3,*b* shows its diffraction pattern, and Fig. 4 shows some of the prominent features of this pattern superimposed upon the reciprocal-lattice section shown in Fig. 2.

It will be seen that the correspondence is quite close, and, in fact, the orientation of the molecule obtained in this way agrees to within a few degrees with that obtained by Robertson[7]. Perfect correspondence is not to be expected, because an ideal molecule has been assumed and there are also errors in the masks themselves. The method is only suggested for use in the initial stages of a structure determination, and, once a rough correspondence has been found, orthodox methods of refinement must then be brought into play.

Phthalocyanine provides a special case for application of the method, in that the unit cell of the projection contains only one molecule, and that the molecule is planar. Discussion of the further problems that arise when these conditions do not obtain will be published elsewhere.

We wish to express our thanks to the Department of Scientific and Industrial Research for a grant towards the building of the apparatus.

C. A. Taylor
H. Lipson

Physics Department,
College of Technology,
Manchester 1. Jan. 26.

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Design of Multiple-Monochromators

Conventional prism monochromators have two main limitations: a limited resolution due principally to the finite size of the prism; and impurity of spectrum owing to light scattered from various optical components, particularly the prism. A great improvement in these two respects can be obtained by a simple method which converts a single-monochromator into a double- or multiple-monochromator.

The principle of the method (for which a provisional patent specification has been lodged) can be illustrated by describing the conversion of a typical monochromator, shown in Fig. 1, to a double-monochromator. When used normally, radiation passes through the entrance slit S_1 and falls on the collimating mirror M_1, which sends a parallel beam to the prism P. The dispersed beam is reflected back on to M_1, which focuses radiation of a given wave-length on the exit slit S_2.

Suppose the mirror M_1 is set so that radiation of wave-length λ_1 falls on the exit slit S_2. Radiation of other wave-lengths will be in focus at other points on the focal curve OA of the mirror M_1. By placing two plane mirrors M_3, M_4 at right angles to each other and with their apex on OA, radiation of a given wave-length λ_2 will be reflected back to M_1, through the dispersing system and finally through the exit slit S_2.

Radiation which has passed only once through the optical system will be referred to as 'first-order' radiation, and radiation which, by means of mirrors M_3, M_4, has been twice through the optical system as 'second-order' radiation. It will be clear that, for a given setting of the mirror M_1, first-order radiation of wave-length λ_1 will pass through the exit slit at the same time as second-order radiation of a different wave-length λ_2. In order to isolate the two orders a

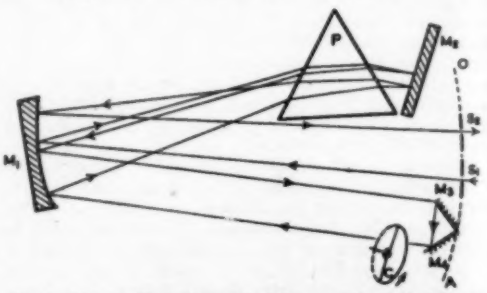

Fig. 1. Diagram illustrating method for converting a single- to a double-monochromator

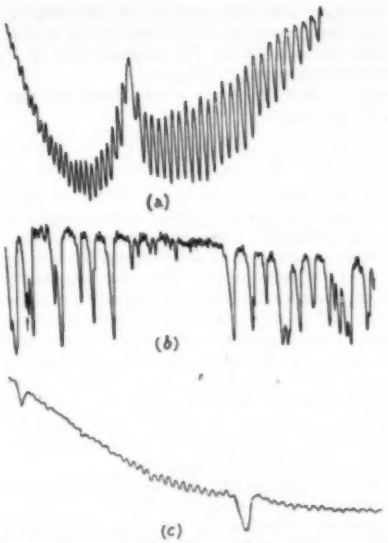

Fig. 2. (*a*) 4·3-μ band of carbon dioxide, using a lithium fluoride prism. The separation of the individual rotational lines is 1·5 cm.$^{-1}$. (*b*) Portion of 6-μ band of water vapour, using a calcium fluoride prism. The lines indicated by the arrow (left) are separated by 0·5 cm.$^{-1}$. (*c*) 15-μ band of carbon dioxide, using a sodium chloride prism. The separation of the individual rotation lines is 1·6 cm.$^{-1}$

rotating chopper is arranged to interrupt the radiation reflected from M_4, and the signal from the detector is passed to an amplifier tuned to the same frequency as the chopper. Thus, the first-order radiation, which is not chopped, gives no signal at the output of the amplifier, and only the second-order spectrum, which is chopped at the correct frequency, produces an output signal.

A Perkin–Elmer infra-red spectrometer (Model 12*C*) has been converted into a double-monochromator by the method described above. Typical spectra obtained are shown in Fig. 2. The resolution obtained is about twice that obtainable with the original instrument, and the scattered radiation is too small to be detected, even at 15 μ, where the scattered light often exceeds 10 per cent of the signal in the first order. By using prisms of fused silica, lithium fluoride, calcium fluoride, sodium chloride and potassium bromide, it is believed that the instrument developed will yield a resolution of better than 1·5 cm.$^{-1}$ over most of the wave-length range 2–25 μ.

The adaptation of the above principle to the construction of a multiple-monochromator will be obvious. A full discussion of the design and performance of multiple-monochromators will be published shortly.

My colleague, Mr. J. L. Farrant, has pointed out that the single-prism type of double-monochromator described above could be readily adapted to Shurcliff's[1] modification of Golay's[2] multi-slit system, and will deal with this subject in a future publication.

A. Walsh

Chemical Physics Section,
Division of Industrial Chemistry,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne. Jan. 4.

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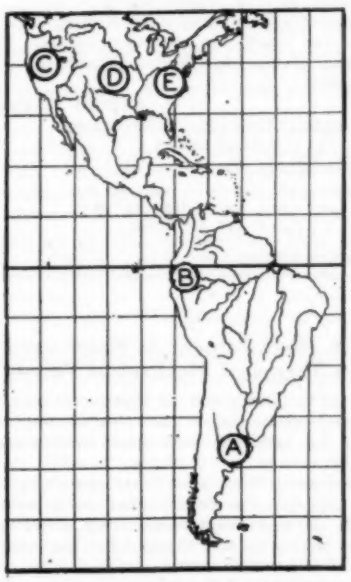
Enhanced Trans-Equatorial Propagation following Geomagnetic Storms

Experimental evidence has been obtained over a relatively large geographical area in the western hemisphere confirming the existence of abnormally high F_2-layer densities during, or shortly after, geomagnetic disturbances. The observed effect of these high F_2-layer densities is to propagate radio frequencies at least 20 per cent above the median maximum usable frequency of the period in question.

It has been found that moderate geomagnetic activity in the equatorial region does not appear to be accompanied by a depression in the penetration frequency of the F_2-layer. Several workers[1] have also shown that the penetration frequency is often increased above the 'normal' for that period. Appleton and Piggott[2] have recently reconciled the variations of geomagnetic ionospheric storm manifestations with latitude. Their studies have shown that in the equatorial region a 'positive phase' or enhancement of the F_2-layer occurs simultaneously with the maximum depression of the F_2-layer densities in the temperate latitudes.

Several hundred observations have recently been obtained by this organization from radio amateurs in North and South America. These observations were taken during the latter part of 1949 in the 6-metre radio-amateur band on frequencies between 50·0 and 51·0 Mc./s. [3].

It has been shown that the maximum usable radio frequencies during the sunspot peak of 1947–48 for transmission via the F_2-layer was of the order of 45·0 Mc./s. in the 'W' zone[4]. During an extremely small percentage of the total time throughout the sunspot peak, communication across the North Atlantic Ocean was possible using frequencies greater than 50·0 Mc./s. [5]. This occurred most frequently during the days of little geomagnetic activity. Analysis of the reports just received showed that communication between North and South America was most fre-



Terminal areas of trans-equatorial propagation during October–November 1949

Date (1949)	Huancayo storms Start*	Cessation*	Activity†	50·0 Mc./s. propagation Start	Cessation	Areas (see map)
Oct. 13	2013	..	*s*	—	—	—
Oct. 16	..	0800	*s*	1426	2005	*A* and *B* to *C*, *D* and *E*
Oct. 27	0450	..	*ms*	—	—	—
Oct. 28	..	0600	*ms*	1306	1745	*A* and *B* to *D* and *E*
Nov. 1	0953	..	*mss*	—	—	—
Nov. 2	..	..	*mss*	1740	1900	*A* to *C*
Nov. 3	..	0500	*mss*	1747	1857	*A* to *C*
Nov. 19	0604	..	*s*	—	—	—
Nov. 20	..	0700	*s*	1353	1630	*B* to *C*, *D* and *E*

* (..) represents continuing storm.
†, storms are described by three degrees of activity : *m* for moderate, *mss* for moderately severe, *s* for severe.

quently affected during, or shortly after, moderately severe, or severe geomagnetic storms.

The accompanying table shows the reported geomagnetic storms at Huancayo and the periods when 50·0-Mc./s. communication was possible. The periods of possible communication during the storm dates represent approximately 70 per cent of the total time when communication was possible between the areas indicated.

It would appear, from these observations, that the enhancement of radio propagation conditions may possibly exist at all longitudes throughout the entire equatorial region.

The 'opening' of frequencies in excess of 50·0 Mc./s. for oblique incidence F_2-layer propagation strongly suggests that the 'positive phase' described by Appleton and Piggott may continue for 12–18 hr. after cessation of the geomagnetic storm. More evidence and further study on this effect are desirable.

This study was made possible by the whole-hearted co-operation of a large number of radio amateurs scattered throughout twelve countries of the western hemisphere. Their interest and assistance in providing the observational material are gratefully acknowledged. The evaluation of the data was performed by the staff of this organization.

The investigations resulting in this work have been sponsored in part by the Geophysical Research Directorate of the Air Force Cambridge Research Laboratories.

Oliver P. Ferrell
Radio Amateur Scientific Observations,
121 S. Broad Street,
Philadelphia, Pa. Jan. 11.

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Absolute Measurement of Microwave Power in Terms of Mechanical Forces

A low-loss cavity having input and output wave guides, and containing a movable element, can, in principle, be used for measuring microwave power absolutely.

It is necessary that in at least one position of the moving element the cavity acts as a reflexionless transition between input and output wave-guides. The force acting on the element in this position is a measure of the power flow.

Let the position of the movable element be specified by a co-ordinate x_3, and let the matching position of x_3 be x_{30}. The component of generalized force acting in the direction of increasing x_3 under these conditions we denote by F_3, defined so that $F_3 dx_3$ is an infinitesimal energy change.

If the output wave-guide is matched, and the power flow is P, we have

$$F_3 = \frac{P}{2c} \cdot \frac{\lambda}{\lambda_{g_3}} \left[- \frac{\partial x_3^{(1)}}{\partial x_3} - \frac{\partial x_3^{(2)}}{\partial x_3} \right].$$

In this expression, c is the velocity of light, λ is the transverse electromagnetic wave-length and λ_{g_3} is the wave-length in the output wave-guide.

The bracketed factor is determined by two auxiliary experiments (distinguished by the superscripts) in which the matched load is replaced by a perfectly reflecting piston at x_3, and a standing-wave indicator is used to locate nodes in the input wave-guide. In the first experiment $x_3^{(1)}$ is given any arbitrary value $x_{30}^{(1)}$, and, with x_3 equal to x_{30}, a node is located by the standing-wave indicator, say at $x_1^{(1)}$. Then x_3 and $x_3^{(1)}$ are adjusted in such a way that the node remains at $x_1^{(1)}$, and from the resulting set of values $\partial x_3^{(1)}/\partial x_3$ is determined at $x_3 = x_{30}$.

The second experiment is similar to the first, except that we take $x_{30}^{(2)} = x_{30}^{(1)} + \lambda_{g_3}/4$.

The general relationship between force and power quoted above can be deduced from the adiabatic invariance of action in a loss-free cavity[1]. It has given satisfactory agreement with other methods in calibrating the radiation-pressure power-measuring apparatus previously described[2].

An interesting special case is the rotary phase shifter described by Fox[3]. If the central 'half-wave plate' section is allowed to rotate on its axis from a suitable suspension of known specific couple, the torque T exerted on it could be measured and would give the power flow according to the formula $P = \frac{1}{2}\omega T$, where P is the power flow and ω the angular frequency. Moreover, there would be no reflexion of power for any deflexion of the movable part in principle, and angles of deflexion exceeding 2π are not excluded.

A. L. Cullen
Department of Electrical Engineering,
University College, London, W.C.1.
Dec. 18.

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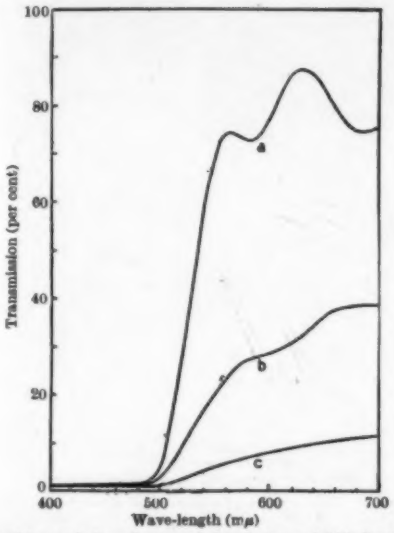
Preparation of Photoconducting Cadmium Sulphide

Cadmium sulphide, when suitably prepared and in the form of relatively large crystals, is an interesting and important photoconducting material, with high sensitivity to many forms of radiation, including visible and ultra-violet light, X-rays, gamma- and beta-rays, etc.[1].

The usual method of preparation is by a vapour-phase reaction at a temperature of 1,000°–1,100° C., between hydrogen sulphide and cadmium in the presence of hydrogen[2]. Yellow hexagonal crystals are obtained in the form of flat plates 0·1 mm. thick and 1 cm. long when the furnace used is 10 cm. in diameter.

A new method has been developed for the preparation of photoconducting cadmium sulphide surfaces, the process possessing considerable advantages over that outlined above. Cadmium sulphide is precipitated from an aqueous solution of cadmium sulphate



Spectral transmission of evaporated cadmium sulphide layers on glass, the sulphide facing the light beam; evaporated at pressures (*a*) less than 10^{-4} mm; (*b*) 5×10^{-4} mm.; (*c*) 5×10^{-3} mm. mercury respectively

by hydrogen sulphide gas, and the precipitate filtered off, washed and dried. The resulting yellow powder is then evaporated *in vacuo* from a molybdenum boat on to clean glass or rock-salt surfaces, the latter when it is desired to remove the substrate by solution in water. Surfaces of any desired area and of thicknesses up to 5×10^{-4} cm. have been prepared in this way.

The photoconducting properties are almost identical with those of crystals prepared by the high-temperature furnace method, providing certain conditions are observed during evaporation, namely, an adequately low pressure and a slow rate of evaporation.

The effect of gas pressure during evaporation is extremely critical, and is shown in the accompanying graph, where spectral transmission curves are given for three surfaces evaporated at pressures of (*a*) less than 10^{-4} mm., (*b*) 5×10^{-4} mm., (*c*) 5×10^{-3} mm. mercury respectively. The colour of the film changes from a pale yellow to black, with a corresponding increase in the specific resistance in the dark (from 10^{-6} ohm^{-1} cm.$^{-1}$ to 2×10^{-3} ohm^{-1} cm.$^{-1}$ respectively). Photoconducting properties are absent or small in samples (*b*) and (*c*). The changes are probably associated with a slight oxidation of the film, for both the colour and the photoconducting properties are completely restored by heating in dry hydrogen at 350° C.

The best sensitivity is obtained for layers evaporated slowly, typical values being 10 amp./watt for a tungsten filament source at 2,600° K., at a field-strength of 1 kV./cm. across a section of the layer 1 mm. wide and 1 cm. long, for a layer evaporated at the rate of 0·01 mgm. per sq. cm. per min.

The process is particularly suitable for the preparation of uniform surfaces of large area suitable for optical measurements for the determination of the type of activating centre, and for use in photoconducting camera tubes, or for the large-scale preparation of photoconducting elements. The process and photoconductivity measurements are being extended to evaporated layers of related selenides and tellurides.

Acknowledgments are made to the Commonwealth Scientific and Industrial Research Organization, Physics Division, for spectral transmission measurements, and the Radiophysics Division for the use of vacuum equipment.

R. E. Aitchison
Electrical Engineering Department,
University of Sydney,
Sydney. Dec. 14.

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Silicone Oil Vapour and Secondary Electron Emission

The current tendency to use oil instead of mercury vapour in diffusion pumps led us to carry out experiments of two kinds on secondary electron emission using silicone oil (*DC*. 703). From our findings, we consider that its vapour will produce obnoxious results on any surface when bombarded by electrons.

In one series of experiments the 'sticking' potential of a fluorescent powder was determined. This potential is, in our case, defined as the higher of the two potentials at which the secondary emission coefficient δ is unity. The pressure was measured by an ionization gauge, which was calibrated in a mercury system, and it gave a reading of 5×10^{-6} mm. mercury in the system used for the experiments.

It was found initially that the values of 'sticking potential' were in quite good agreement with many of the published figures[1]. However, under electron bombardment the secondary emission falls within thirty minutes, and the 'sticking potential' drops from some 8–12 kV. to 2·5 kV. The rate of fall is dependent on the bombarding current density which, in these experiments, ranged from 0·8 μamp./cm.^{2} up to 16 μamp./cm.^{2}. Specimens bombarded at the higher currents showed slight brown staining; but at lower values of current no discoloration was visible. A similar fall was observed on 'Hysil' glass, although in this case the drop was very small, the 'potential' falling from 2·4 kV. to 1·8 kV. A nickel cap which was bombarded in the vacuum showed interference colours on its surface, in patterns corresponding to the bombarded areas. All these measurements were reproducible.

In the other series of experiments, the secondary emission coefficient was measured for various surfaces in an 'orbital beam' electrode system[2]. The electrodes and system were much more highly degassed than was possible in the first series of experiments. A tungsten filament was used as a source of primaries, and the vacuum produced during these experiments gave readings corresponding to a pressure of $2–3 \times 10^{-6}$ mm. mercury. One of the secondary emissive substances investigated was a mixture of magnesium and barium oxides[2]. On heating the secondary cathode to 1,000° C., and allowing it to cool, the value of δ was found to be about 5, but it could not be measured accurately on account of the rapidity of fall under electron bombardment. In a matter of seconds, δ decayed to approximately 1·5. The process of decay and recovery by heating could be repeated several times until eventually, after one or two hours bombardment, the secondary cathode became coated with a dark deposit. This deposit was most intense on the more heavily bombarded areas. The value of δ was then permanently lowered, even after very strong heating. Dark marks were also seen on the uncoated metal of

the secondary cathode where electron bombardment had occurred. The nature of this black deposit was not determined; but it might be noted that the same deposit was also found on the anode and glass bulb of the ionization gauge. Furthermore, the use of a water-cooled baffle in this system produced no change in the phenomena.

Thermionic emitters such as tungsten and alkaline earths are not seriously affected by the silicone, the emission being as good as in an ordinary demountable system. For example, over long periods, the tungsten filament of the ionization gauge could be operated as a thoriated emitter.

It is supposed that a silicone film on the bombarded electrode is decomposed, whereas a thermionic cathode remains hot enough to prevent much silicone remaining on it. It would seem, therefore, that great care should be exercised in interpreting the results of experiments which are made in vacua containing silicone vapour.

We wish to acknowledge the continued interest and help of Drs. H. Moss and C. S. Bull in the above work, and to thank Electronic Tubes, Ltd., for permission to publish these results.

A. Lempicki
A. B. McFarlane

Electronic Tubes, Ltd.,
Loudwater, High Wycombe,
Bucks. Jan. 11.

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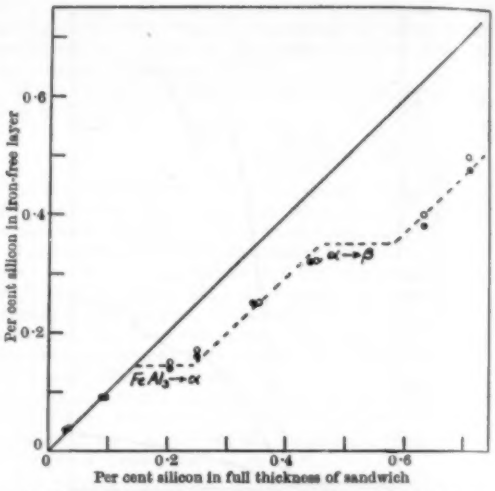
Determination of Phase Boundaries in Solid Alloy Systems by a Diffusion Technique

The accurate determination of equilibrium conditions in solid alloys containing three or more elements sometimes presents considerable difficulty when the alloying metals are present in only small proportions. Direct X-ray examination is not always feasible, and indirect methods, such as the measurement of electrical conductivity, may fail because the changes in properties are often comparatively slight.

We have recently been investigating the equilibrium constitution of aluminium–silicon–iron alloys containing 0·5 per cent iron and 0–0·75 per cent silicon, that is, within the range of commercial-purity aluminium, at temperatures from 450° to 600° C. The technique used is both direct and simple, and since, so far as we can ascertain, it has not previously been applied in this way, a brief description may be of interest.

The principle of the method is to segregate the co-operating phases of an alloy on a scale which, although it allows equilibrium to be attained by a diffusion anneal, is yet sufficiently coarse to allow differential chemical analysis to be carried out without difficulty. This can be done very simply by hot-rolling together, and so welding, fairly thick plates of different alloys to form a 'sandwich', the alloys being chosen so that certain phases will appear only in one layer of the composite sheet. The total analysis of the sandwich corresponds, of course, to the composition of alloy it is desired to investigate. The composite sheet is rolled down to an appropriate thickness, annealed until diffusion is complete, and the separate layers then analysed to determine the final distribution of the mobile element or elements.



Results on alloys containing 0·5 per cent of iron heat-treated at 475° C.: ●—●—, for 320 hr.; ○—○—, for 500 hr.

In the aluminium–silicon–iron system, the solubility of iron is very small, and $FeAl_3$ appears at quite low concentrations. All that is needed in this case is to determine the distribution of silicon between the aluminium solid solution and the $FeAl_3$ phase, with which it is known to form, under appropriate conditions, two ternary compounds α(Fe–Si) and β(Fe–Si) [1], and may also show solid solution effects. The sandwiches prepared, therefore, consisted of only two layers, of equal thickness, one containing 1·0 per cent iron and the other twice the concentration of silicon required in the final alloy.

At 550° and 600° C., material 1·0 mm. thick was used. Samples for chemical analysis could then be taken from both sides of the heat-treated sheet by skimming in a lathe. At lower temperatures, the thickness was reduced to 0·25 mm. to allow equilibrium to be attained in a reasonable time, and the procedure then adopted was to fix the sheet to a metal block with adhesive, with the iron-rich side uppermost, and to grind it down to a thickness of about 0·1 mm. A determination of silicon on the $FeAl_3$-free side remaining and on the full thickness of the sandwich gave all the required information.

The accompanying graph shows the results obtained in some tests at 475° C. In this we have plotted the percentage of silicon found in the $FeAl_3$-free side against the total silicon determined on the full thickness of the sheet. The silicon combined with the $FeAl_3$ is then given by the horizontal displacement of the experimental points from the line which has been drawn in at 45°. It will be seen that the approximate range of silicon contents over which α(Fe–Si) and β(Fe–Si) are stable at this temperature can be determined without difficulty from the data.

It is hoped that it will be possible to publish elsewhere a detailed account of the results obtained by the application of this technique.

C. E. Ransley

Research Laboratories,
British Aluminium Co., Ltd.,
Chalfont Park,
Gerrards Cross,
Bucks. Jan. 5.

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Molecular Orientation and Light Absorption

RECENT discussions by several authors[1-5] have stressed the importance of considering the orientation of molecules in the measurement of light absorption in cytological material.

In a system of molecules having parallel orientation (anisotropic system), the incident vibration is decomposed into two perpendicular components. These components are differently absorbed (dichroism). In many cases, however, the light absorption of such systems is measured with unpolarized light. If the transmission (I/I_0) of one component is a and the other b, the total transmission for unpolarized light can be shown to be $(a + b)/2$. If the same molecules are randomly orientated in the same space, the transmission will be $\sqrt{a.b}$. Thus, by measuring the light absorption of an anisotropic system using unpolarized light, a systematic error will be introduced, depending on the ratio of a to b. The magnitude of this error must be investigated experimentally for each special case.

The following summarizes some results for nucleic acids. The preparation used was deoxyribose nucleic acid made according to Hammarsten. Two types of experiments were carried out.

In the first, nucleic acid molecules in solution were orientated by streaming in the apparatus designed by Signer[7] (1,100 r.p.m.; radius of rotating cylinder, 24·75 mm.; distance between rotating and fixed cylinder, 0·5 mm.; light-absorbing layer, 50 mm.). As a light-source for 260 mμ a Beckman spectrophotometer (band-width 1 mμ) was used. The intensities were measured by a 1*P*28 photomultiplier. The amplified photocurrent was recorded by an Esterline Angus meter (0–5 m.amp.). An interchangeable Glan prism was inserted between the streaming apparatus and the photomultiplier tube. The dichroism and the absorption of unpolarized light of orientated and unorientated molecules in the same solution were measured. The results of a typical experiment are presented in the accompanying table.

The second type of experiment was made with an apparatus especially devised for microscopic specimens. The constructional details of this apparatus will be published elsewhere[6]. The molecular orientation was brought about by stretching a nucleic acid gel into microscopic fibres or strips. Some results of measurements similar to the above are summarized in the table.

It is evident from the first type of experiment that, with moderate degrees of orientation, giving a dichroism (E_a/E_b) of 1·3, the error lies within 2 per cent at a transmission of 50 per cent at 260 mμ (in the direction of higher transmission values).

In the second type of experiment it is interesting to note the high values of dichroism in freshly made fibres. The deviation or error calculated from these values will be 6 per cent at 50 per cent transmission. At lower transmission values, however, the deviation will be considerable.

In cytological material (with few exceptions, for example, sperm heads), the dichroism of nucleic acid generally is very low[1], detectable only with specially designed instruments[6]. Thus, it seems clear that the effect of molecular orientation on the cellular nucleic acid absorption of unpolarized light does not introduce any serious error, such as has been assumed[2,3].

B. THORELL
F. RUCH

Karolinska Institutet,
Stockholm.
Jan. 11.

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Applications of Multiple-Beam Interferometry

Two recent communications on applications of multiple-beam interferometry, one by Bruce[1], the other by Bruce, Macinante and Kelly[2], call for critical comment.

Bruce has described two applications of transmission-like multiple-beam interference fringes in reflexion. These are applied to (*a*) the method I have already described[3] for measuring the thickness of thin films, and (*b*) the interferometric method for measuring oscillations described by Tolansky and Bardsley in 1948 [4a].

Doubtless this modification has some advantages in very limited cases; but it will be of interest to find whether the method used (which, incidentally, is not fully described) can really be extensively employed in the examination of the complex topographies now so frequently under examination with multiple-beam interferometry. Although the application is of interest, the principle of the method of converting reflexion into transmission-like fringes by cutting out beams is not at all new. It was, of course, first discussed in detail by Otto Lummer fifty years ago[5]. I have long been familiar with this, having taught it to a succession of students for more than fifteen years, and having used it in interferometrical studies occasionally, though not to very much advantage. In simple low-magnification cases it is not difficult to cut out individual beams; but with the higher-power microscopic observations now often used the

Experiment	Orientated molecules: Dichroism Transmission (260 mμ) $a = \frac{I_a}{I_0}$	$b = \frac{I_b}{I_0}$	Extinction quotient $\frac{-\log a}{-\log b}$	Transmission (u) of unpolarized light (260 mμ) measured	calc.	Unorientated molecules. Transmission (v) of unpolarized light (260 mμ) measured	calc.	Per cent deviation $\left(\frac{v-u}{v} \cdot 100\right)$
I (streaming)	0·11	0·06	1·3	0·09	0·082*	0·09	0·078*	5
II (fibres)	0·72	0·36	3·2	0·53	0·54	—	0·51	6
,,	0·34	0·03	3·2	—	0·18	—	0·11	64

* Calculations give approximate values, as the molecules are not completely orientated by this method.

matter may not be so simple and may well lead to diffraction anomalies in the image.

Bruce is too severe in his criticism of reflexion fringes. I have shown in connexion with reflexion Fabry–Perot fringes[6,7] that the critical factor affecting visibility is not the reflectivity but the absorption of the front film. Although the quality of reproduction in the note by Bruce makes it difficult to form a reliable judgment, it appears to me that his silver films have too big an absorption. With correct attention to this detail, it is possible to secure very sharp reflexion fringes of high contrast (see illustration of page 149 of ref. 3), and they can be, and have been, used quite well for oscillation experiments (see ref. 4).

The second communication[2], by Bruce, Macinante and Kelly, describes the use of a stroboscopic method with multiple-beam interference fringes for studying oscillations. The authors are obviously not aware of the fact that in April 1949 I gave an account[8,9] of the way Mr. Bardsley and I have for some time been successfully using stroboscope methods in combination with interferometric studies on oscillating crystals. As I have already pointed out, the stroboscopic method we use not only permits larger amplitude measurements to be made, but also, and much more important, reveals relative phases[4b].

S. Tolansky

Royal Holloway College,
Egham.
April 10.

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Decomposition of Radioactive Octamethylpyrophosphoramide in Living Plants

Gardiner and Kilby have described[1,2] the synthesis of the systemic insecticide *bis*(*bis*-dimethylaminophosphonous) anhydride (octamethylpyrophosphoramide) in radioactive form (with phosphorus-32) and its application to the study of its uptake by living plants[3]. We also have experimented along these lines, but have extended our investigations to the study of the chemical fate of the substance, using for this purpose activities of about 400 μC./gm. to obtain the necessary sensitivity in analysis. Preparative details will be published elsewhere.

In vitro, acid hydrolysis of the phosphoramide occurs at a rate determined by $k = 3{\cdot}6 \times 10^{-3}$ [H$^+$] min.$^{-1}$ at 25° C., and alkaline hydrolysis by $k = 4{\cdot}7 \times 10^{-3}$ [OH$^-$] min.$^{-1}$ at 100° C. Only powerful oxidizing agents and halogens react more rapidly. Water itself does not react at a measurable rate. Thus in the *p*H range of plant tissues, 4·5–7·0, the half-life *in vitro* would be more than eight years.

We find, however, that only about 10 per cent of the toxic compound originally absorbed by plants in vigorous growth is present unchanged four weeks after spraying. Up to a further 50 per cent is present as decomposition products. The rate of decomposition is considerably dependent on state of growth and is particularly slow in winter-dormant plants, facts which are consistent with the decline in insecticidal activity already established[3]. The contrast with the stability in non-living solutions indicates that some enzymic process is responsible for the decomposition in plants.

The water-miscible amide in dilute solution at 25° C. partitions 7 : 1 in favour of chloroform from water and 23 : 1 from *N* aqueous sodium hydroxide. All products of inanimate hydrolysis carry a hydroxyl group on the phosphorus atom and are therefore retained by aqueous alkali, and we have found no evidence of any metabolite soluble in chloroform but having a different partition ratio with water. To estimate the toxic material, therefore, plant samples are macerated with water, filtered and the aqueous extract, containing most of the activity, made alkaline and extracted with chloroform. The radioactivity of aqueous and chloroform layers is measured in an annulus-type Geiger–Müller tube. With a small correction for incomplete extraction, the chloroform count gives the amount of unchanged compound. Further partition experiments show no evidence of any other chloroform-soluble compound.

The decomposition products are mostly precipitated by calcium salts in alkaline solution. Some light is thrown on the mechanism of decomposition in the plant by following the fate of hexamethylorthophosphoramide. This has similar physical properties to the pyro-compound, but is not hydrolysed by alkalis, as this is a property of the P—O—P bonding. We find that the living plant decomposes the ortho-amide as rapidly as the pyro-. When an aqueous extract normal in sodium hydroxide is partitioned exhaustively with chloroform, little of the decomposition products are in this case not extractable, most appearing as a compound with partition coefficient (chloroform/*N* aqueous sodium hydroxide) of 1·2 as against 17·0 for the ortho-amide. Hydrolysis of the P—N links must give POH groups, products containing which on partition go solely into *N* sodium hydroxide. The initial site of attack by the enzymes is therefore not the P—N link but either the N—C or C—H links. Substitution of carbon by hydrogen or hydrogen by hydroxyl decreases the partition in favour of chloroform. The absence from the pyro-amide products of any substance extractable by chloroform from alkali may result from instability of the P—O—P links during the action on the N—C—H system.

It is therefore probable that the mechanism of decomposition is wholly different from that of inanimate hydrolysis. Attack on the N—C—H system is not surprising in view of the known abundance of methylamines in plants, whereas the unusual N—P link is much less likely to find an enzyme designed to attack it.

Our thanks are due to Mr. D. Lane and Mrs. M. V. Llewellyn for assistance in the preparative and analytical work; also to the directors of Pest Control, Ltd., for permission to publish this note.

G. S. Hartley
D. F. Heath

Pest Control, Ltd.,
Harston,
Cambridge.
Dec. 20.

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Spontaneous Gelation of Alkaline Casein Dispersions

In a communication in *Nature* of February 10, Plomley, Higgins and Hayes describe the dependence of viscosity and rate of gelation on *p*H. Their results are in general agreement with those obtained in this laboratory for lactic casein and denatured peanut protein spinning dopes; dopes to be spun into fibres must obviously have considerable stability to allow time for filtration and de-aeration.

The authors mention that search for the specific groups concerned in the gelation process is proceeding. There are a number of indications that the specific group concerned in gelation is the sulphydryl group[1]. Oxidation catalysed by oxidative enzymes increases the tendency to gel:

$$R-SH + O + HS-R^1 = R-S-S-R^1 + H_2O.$$

Milk casein and peanut protein dopes containing sodium sulphide are much more stable than dopes of similar alkalinity not containing sodium sulphide; the latter agent would inhibit the formation of disulphide bonds.

There is a *p*H (*c.* 12·5) giving maximum stability for both milk casein and peanut protein dopes; if milk casein dope containing *c.* 20 per cent lactic casein and 0·50 per cent free caustic soda is made more alkaline by the addition of 50 per cent more caustic soda, the dope becomes a gel after two days at 25° C.; but if the additional alkali is in the form of sodium sulphide, the change in viscosity is quite small. At very high alkalinity, the ultimate decline in viscosity is likely to be due to hydrolysis.

Thomson and Traill[2] have explained the peculiar behaviour of peanut and other seed protein dopes in terms of denaturation and chain rupture. Both these factors are important; but the irreversible nature of the gel suggests cross-linkage formation, and the most likely link appears to be the well-known disulphide bond. In comparing denatured peanut protein dopes with milk casein dopes, both types of dispersions show similar sequences of viscosity changes; but the peanut dispersions are more sensitive to change, and this would be in accordance with their higher cystine content.

R. L. Wormell

Courtaulds, Ltd.,
Coventry.
April 2.

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Electrolytic Oxidation and Reduction of some Pyridine Compounds

As part of an investigation for developing satisfactory procedures of preparing 2-, 3- and 4-pyridinealdehydes, attention was turned to the electrolytic oxidation and reduction of pyridine compounds. After consideration of commercially available pyridine derivatives, studies were made of the electro-oxidation of 2-, 3- and 4-picoline and of 2-vinylpyridine and the electro-reduction of picolinic, nicotinic and *iso*nicotinic acids. Inasmuch as the results do not show promise of being successful with respect to the primary object, the work has been abandoned. Nevertheless, some of the observations are interesting, although several points need further inquiry.

Other than minor modifications for electrolyses carried out at elevated temperatures, the basic arrangement consisted of a clay porous cup, for one cell compartment, sitting or suspended in a beaker, which served as the other cell compartment. A mechanical stirrer was used for agitation. More than a hundred electrolyses were conducted to observe the effect upon the yield of aldehyde when varying separately the type of electrodes, amperage, current-density, applied E.M.F., temperature, concentration of pyridine derivative, time of electrolysis, type of electrolyte at anode or cathode, or addition of an agent to precipitate the aldehyde as it is produced.

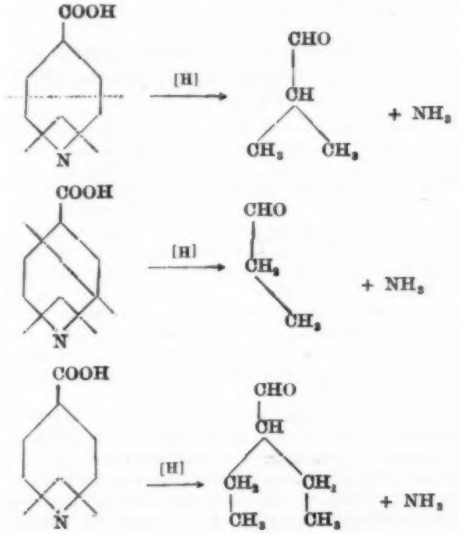
Aliquots from the solutions in the cathode compartment in reductions and from the anode compartment in oxidations were analysed for carbonyl and nitrogenous products. A quantitative determination of the former was made by producing and weighing the precipitated 2,4-dinitrophenylhydrazone, and its qualitative identification was made through mixed melting points with authentic samples. Ammonia was detected through its picrate by mixed melting points with known samples of ammonium picrate.

Products Obtained in the Electro-reduction of *iso*Nicotinic Acid

Type of cathode	Applied E.M.F. (volts)	Product
Tin foil	6	23·4% CH_3CH_2CHO
Lead plate	6	Identity unknown*
Platinum black	6	10·7% $(CH_3)_2CHCHO$
Mercury-pool	5	28·7% "
"	4	21·4% "
"	3	$(CH_3CH_2)_2CHCHO$†

* Known not to be any of the other aldehydes in this table.
† Identity not conclusive.

In the reductions, the surprising observation was the profound effect that the type of cathode and applied E.M.F. has upon the mode of cleavage of the nucleus of *iso*nicotinic acid. In the accompanying table are listed the aldehydes isolated as their 2,4-dinitrophenylhydrazones in the reduction of *iso*nicotinic acid. It is noteworthy that the pyridine nucleus is cleaved in various ways, depending upon the conditions. In each case ammonia was also produced. Wibaut and Boer[1] and F. Sorm[2] have



also studied the electrolytic reduction of *iso*nicotinic acid, and although the conditions in the three independent investigations do not differ greatly, the results from the three studies are different. To determine at what minimum potential production of aldehyde takes place and therefore, perhaps, avoid reduction of the ring, electrolyses were performed with a mercury-pool cathode at 2 volts. Ammonia was easily detected; but the test for aldehyde was negligible at E.M.F.'s below 2·4 volts, and the aldehyde was still aliphatic.

In the oxidations of the picolines, the gamma isomer gave the best results; but the highest yield of 4-picolinealdehyde was only 16·3 per cent. By making analyses at half-hour intervals during the electrolyses, it was found that the concentration of aldehyde reaches a maximum after about two hours and then decreases rapidly to a low level.

In the oxidations of 2-vinylpyridine, analyses were also made for a glycol with periodic acid and silver nitrate. Assuming the glycol to be 2-pyridyl-ethylene glycol, the highest yields of glycol and 2-pyridinealdehyde obtained were 6 and 3 per cent, respectively. Relatively high potentials were required for the oxidations of 2-vinylpyridine, and this resistance towards oxidation of the side-chain is also observed in its resistance to chemical oxidation. For example, 2-vinylpyridine and 4-stilbazole were found to be inert towards hydrogen peroxide in the presence of osmium tetroxide.

This work was supported by a contract from the Office of Naval Research, U.S. Navy Department. It is described in a thesis (A. J. L.) presented in partial fulfilment of the requirements for the degree of master of science to Howard University in 1949, and was presented before the Division of Organic Chemistry of the Washington Chemical Society, November 1949.

Lloyd N. Ferguson
Alma J. Levant

Department of Chemistry,
Howard University,
Washington 1, D.C.
Dec. 7.

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Enzymatic Formation of Glutamohydroxamic Acid from Glutamine in Mammalian Tissue

The presence of enzymes which catalyse the exchange of the amide group of glutamine and asparagine with amines[1-3] has been shown in cell-free extracts of micro-organisms. The enzymatically catalysed exchange can be easily detected and assayed with hydroxylamine as the acceptor amine, since the γ-glutamo and β-asparto hydroxamic acids produced give the colour reaction with ferric chloride characteristic for hydroxamic acids. The terms 'glutamo-' and 'asparto-transferase' activities were proposed for these enzymatic potencies, since the mechanism of the exchange can be visualized as a transfer of the amino-acid radical from one amine to another.

The rate of enzymatic exchange (cell-free extracts of *Proteus vulgaris*) is not influenced by the addition of phosphate or manganous or magnesium ions.

We now wish to report on the presence (and some of the properties) of the enzyme system showing glutamotransferase activity in mammalian tissue. Whereas homogenates of mammalian tissues with isotopic ammonia and normal glutamine as substrates promoted exchange of the amide group with ammonia (isotopic), the enzymatic formation of hydroxamic acids with hydroxylamine could not be unequivocally demonstrated in such tissue preparations. Aqueous extracts of acetone-dried powder of sheep's brain, liver and kidney showed no activity whatsoever. However, the addition of manganous salts (but not of barium, calcium, magnesium, zinc, copper or cobalt) activated the transferase activity, which was enhanced considerably by the addition of phosphate. Phosphate alone, without manganese, did not activate the enzyme. A potent enzyme extract may be obtained by the extraction of acetone-dried tissue with water followed by precipitation at *p*H 4·2 (acetate), solution of the precipitate in water, and dialysis of the solution against water. By this procedure, enzyme extracts potent after activation with manganous salts and phosphate have been obtained from sheep's brain cortex, sheep's liver and kidney cortex, mouse's liver and transplanted mouse sarcoma ✠ 180, kindly provided by Dr. A. Gellhorn (see table). It is noteworthy that these enzyme preparations (brain cortex) did not show any glutaminase activity when tested under optimal conditions (*p*H 8, phosphate concentrations 0·1 molar).

Glutamohydroxamic Acid formed (micromoles) from Glutamine in Cell-free Extracts of Mammalian Tissues

	Sheep's brain cortex	Sheep's liver	Sheep's kidney cortex	Mouse's liver	Mouse sarcoma
Complete system	14·1	3·8	1·7	9·0	2·2
Without phosphate	1·3	0·6	0·1	4·3	0·6
Without manganous ions	0	0	0	0	0
Without phosphate and manganous ions	0	0	0	0	0
Glutamic acid instead of glutamine	0	0	0	0	0

The complete system contains, per 2 ml.: glutamine, 40 micromoles; hydroxylamine, 20 micromoles; phosphate and manganous chloride, 10 micromoles; 0·05 molar acetate, *p*H 5·5; 0·3 ml. of tissue extract corresponding to 0·1 gm. acetone-dried tissue powder. Incubation, 2 hr. at 35°.

Though it was not possible to decide on the basis of the available evidence whether glutamotransferase activity in cell-free extracts of bacterial origin is associated with glutaminase activity, the two activities can be easily separated in mammalian tissues. The enzyme extract did not catalyse the transfer of the glutamyl radical from glutathione to hydroxylamine, a finding of interest in view of the transfer of the glutamyl radical of glutathione to other amino-acids by enzymes present in sheep's kidney extracts[4]. The optimum *p*H for glutamotransferase activity is about 5·5 (optimum *p*H for bacterial glutamotransferase is about 8).

Stumpf[5] has recently described an enzyme from sugar pumpkin seedlings which transfers the glutamyl radical from glutamine to hydroxylamine and also exchanges the amide-group with isotopic ammonia. This enzyme is active only in the presence of phosphate (or arsenate) and manganese. Whether the activation of the enzyme from mammalian tissues by manganese alone and the enhancement of this activation by phosphate point to an essential difference between the enzyme systems from mammalian and plant tissues cannot be decided at present. Purification and characterization of the protein fraction of mammalian tissues endowed with glutamotransferase

activity will also show whether these enzyme potencies belong to the group of enzymes responsible for the transfer of the glutamyl radical of glutathione to other amino-acids[4] and for the hydrolytic splitting of the tripeptide[6].

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MOGENS SCHOU*
NATHAN GROSSOWICZ†
ABEL LAJTHA
HEINRICH WAELSCH
New York State Psychiatric Institute
and Department of Biochemistry,
College of Physicians and Surgeons,
Columbia University, New York.
Dec. 4.

* Fellow of the National Institutes of Mental Health.
† Fellow of the National Vitamin Foundation.

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Mechanism of Hydrolysis of Benzoyl Chloride

THE following general conclusions emerge from the extensive work on the alcoholysis of substituted benzoyl chlorides[1]: (*a*) the changes in velocity constant with substituents are similar in all the various solvents used; (*b*) these changes fully support the contention that the reaction is a bimolecular S_N2 process.

A similar order in velocity constants is not observed in the hydrolyses in 50 per cent acetone[2] and, moreover, the order is difficult to interpret in terms of any one mechanism[3]. It has been suggested[3,4] that this is due to a change to a unimolecular S_N1 process, particularly when the chloride is substituted by methyl or methoxy groups. If this is true, this tendency should be largely repressed on changing to a solvent of low dielectric constant; and if the reaction then proceeds mainly by the S_N2 process, the rate-order should be the same as for the alcoholysis.

Substituent *p*-position	95 per cent aqueous acetone ($10^5\ k_{25}$)	40 per cent alcohol 60 per cent ether[5] ($10^5\ k_{25}$)	50 per cent aqueous acetone[5] ($10^4\ k_0$)
CH_3O	2·92 *(2·64)	5·3	—
CH_3	2·69 *(3·46)	6·43	12·5
H	5·10	10·8	4·33
Br	15·5	22·3	4·0
NO_2	169·0	203·7	50·0

* 95 per cent dioxan solution (refers to 5 ml. H_2O made up to 100 ml.). Velocity constants k at 0° and 25° expressed in sec.$^{-1}$ units.

The results in 95 per cent acetone show that, with the exception of anisoyl chloride, the predicted order is obtained. On replacing the acetone by dioxan, thus giving a solution with a much smaller dielectric constant, anisoyl chloride hydrolyses more slowly than toluoyl chloride, showing that a complete reversal in velocity order may be achieved. It is of interest to note that the bimolecular reaction with *p*-toluoyl chloride proceeds somewhat faster in the dioxan solution ($D \sim 6{\cdot}5$) than in the acetone solution ($D \sim 24{\cdot}5$), which would be difficult to explain in the case of a unimolecular ionization reaction.

On increasing the water content of the medium, the S_N1 mechanism readily preponderates in the most favourable cases, so that in 50 per cent aqueous acetone only the *p*-nitro compound is reacting entirely by the S_N2 mechanism. On this basis, the methyl-, methoxy- and bromo-compounds and the unsubstituted chloride react almost entirely by the unimolecular process.

We wish to acknowledge the financial help received from the Central Research Fund, and hope to report this work in detail elsewhere.

D. BROWN
R. F. HUDSON
Chemistry Department,
Queen Mary College,
London, E.1. Jan. 12.

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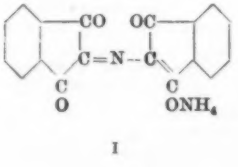
Possible Artefacts introduced by the Ninhydrin and Alloxan Reactions in Histochemical Applications

SINCE the work of Berg[1], the ninhydrin reaction has been commonly used as a histochemical test for the α-amino-acid groupings of proteins. The reaction of proteins with alloxan, giving rise to murexide, has already been criticized by Romieu[2] for lack of specificity and by Giroud[3] for the diffusion of the colour.

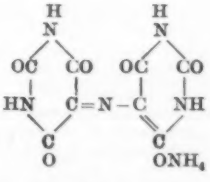
Our own experience shows that for two reasons caution is necessary when interpreting the results. The first is that the reaction products both of ninhydrin and alloxan with the α-amino-acid groups of proteins are to some extent soluble in water and thus may be adsorbed on cellular structures which are not the site of the reaction. The second is that other cellular structures, containing proteins but lacking affinity for the coloured reaction products, will fail to stain. In both cases the microscopical picture is misleading. This can be clearly demonstrated on granules of the blood eosinophiles of the horse and the frog. These structures give a very strong ninhydrin and a weaker alloxan test[4].

The chemical constitution of the reaction product of ninhydrin with amino-acids has been identified as the ammonium salt of 2-(1.3 diketoindanylidene-amino)-indandione[5] (I).

The reactions between proteins and alloxan give rise to the formation of murexide, the ammonium salt of purpuric acid, which has a very similar structure (II).



I



II

The reaction mechanism has been elucidated by Hurtley and Wotton[6]. By means of these compounds in pure solutions, we obtained the same picture as when applying the histochemical test with ninhydrin and alloxan. In these experiments the staining of the eosinophilic granules is not due to any chemical reaction of the amino-acid groups but to an adsorption process. It is thought that the binding of the anionic dye, eosin, is due to electro-adsorption of this substance on positively charged cellular structures[4], in the same way that basic dyes are fixed on negatively charged substances[7]. It is therefore not surprising that other anionic dyes, such as the ammonium salt of 2-(1.3 diketoindanyl-ideneamino)-indandione and the ammonium salt of purpuric acid, are also fixed by eosinophilic structures.

The ammonium salt of 2-(1.3 diketoindanyl-ideneamino)-indandione was prepared by the slightly modified method of Ruhemann[8]. Murexide was prepared according to Wöhler and Liebig[9] (modified).

Smears of horse leucocytes, fixed in methanol, were stained for 10 min. with 7×10^{-4} *M* of the ninhydrin derivative. The eosinophilic granules were very strongly coloured. Erythrocytes, occasionally present, stain faintly (as in the histochemical ninhydrin test). As can be predicted from the staining mechanism, the blue dye is completely displaced by strong concentrations of eosin ($1{\cdot}54 \times 10^{-3}$ *M*). Moreover, it can be washed out with ethanol. When eosin is applied first, and the blue dye afterwards, there is a partial displacement of eosin, and the resulting colour of the eosinophilic structures is a uniform purple. Remarkable staining effects could be obtained with less concentrated eosin solution (10 mgm./25 ml.).

An application of eosin on smears, previously stained with the blue compound, completely displaces the dye in the erythrocytes but only partially in the eosinophilic granules. Their inner part remains blue, while their outer layer is pure red. This points to the heterogeneity of the granules already demonstrated by other means[4]. Further evidence for this fact is furnished by extraction with an ethanol–ether mixture, which strongly reduces the affinity for eosin but not for the blue dye.

The curious staining effect may be explained by a stronger affinity of the inner parts of the granules for the ninhydrin derivative. The same effect is obtained by staining the granules with eosin after staining them by the usual histochemical ninhydrin reaction.

Similar results were obtained with murexide solutions, especially with frog leucocytes.

In our opinion, the interpretation of histochemical protein localization obtained by the ninhydrin and alloxan test is very difficult, and our own results on the cytochemistry of blood eosinophiles[4] require re-examination.

R. Vercauteren

Biochemical Laboratory,
Veterinary College,
University of Ghent.
Jan. 4.

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A New Anti-Proteolytic Factor in Soya Beans

Aqueous extracts of raw soya beans have been shown to be capable of inhibiting proteolysis of casein by pancreatin[1] and trypsin[2]. According to Read and Haas[3], they possess inhibiting action on trypsin and the proteinase of taka-diastase, but not on papain or bromelin.

With a gelatin substrate, I found in 1947 a marked inhibiting power in aqueous soybean extracts not only on trypsin but also on papain. Subsequent work has confirmed this finding, in contradiction of the results of Read and Haas, and has extended it to the proteolytic enzymes of malt flour. More recently, a certain amount of evidence has been obtained that the inhibiting factor is effective on papain and the proteolytic enzymes of wheat flour, acting on a gluten substrate.

The anti-papain factor is heat labile, and apparently more so than the anti-tryptic factor which has been examined in detail by Ham[2], Kunitz[4], Bowman[5] and others. The existence of an anti-papain factor in raw soya beans appears not to have been noticed before.

It is hoped to publish full details of this work elsewhere.

E. M. Learmonth

British Soya Products, Ltd.,
150/2 Fenchurch Street,
London, E.C.3. Jan. 12.

[1] Bowman, *Proc. Soc. Exp. Biol. and Med.*, **57**, 139 (1944).
[2] Ham, *J. Biol. Chem.*, **153**, 505 (1944).
[3] Read and Haas, *Cer. Chem.*, **15**, 65 (1938).
[4] Kunitz, *Science*, **101**, 668 (1945); *J. Gen. Physiol.*, **29**, 149 (1946).
[5] Bowman, *Proc. Soc. Exp. Biol. and Med.*, **63**, 547 (1946).

Fate of Radioactive Protein in the Animal Body

Protein tagged with radioactive iodine (iodine-131) is proving useful in immunological research because of its ready detectability[1]. Also the firm substitution of the iodine in the tyrosine molecule renders conclusions based on the occurrence of radioactivity in the tissues more acceptable as evidence of the presence of the antigen or its partial breakdown products than has been the case with arsenic and dye tracers[2]. The application of various methods including paper chromatography to the study of the fate of iodinated antigens has produced results which appear of general interest.

In the present investigation, the fate of tagged antigenic protein has so far been followed in normal rabbits. The proteins used have been purified bovine albumin, human γ-globulin and homologous whole serum. In agreement with recent American work[3], it has been found that after intravenous injection much of the protein is removed from the blood-stream within forty-eight hours, and that there is a concomitant rise in the radioiodine content of the thyroid gland and the urine. The iodine-131 appeared in the urine of all the animals studied within thirty minutes of the injection. The excretion of iodine was greater when a foreign protein was used. The excreted products were freely dialysable through 'Cellophane' and were not precipitated by protein precipitants, a feature noted also by Crampton and Haurowitz[4].

For further study of the substances excreted, paper chromatograms of the urine were set up on Whatman 3 *MM*. paper and run overnight in phenol saturated

with water. On development with ninhydrin and heat, certain traces of purple indicated amino-compounds; but the most conspicuous feature was always the presence of bright yellow spots or streaks which differed in size and position with the protein injected. In normal uninjected animals, the most conspicuous of these was the lower (R_F 0·40–0·48), but a fainter one was also present (R_F 0·73–0·78). After injection of albumin containing iodine-131, the lower spot was the more conspicuous, and after globulin containing iodine-131 the upper was usually so. With homologous serum containing iodine-131, the spots differed little from those in normal urine. Chromatograms were scanned with a β-particle counting Geiger–Müller tube placed directly on the paper. Counts were made at closely placed sites along the trace. With the foreign proteins it was found that approximately 50 per cent of the activity was in a spot (R_F 0·05–0·10) shown by a comparative tracer to represent inorganic iodine. With albumin injections a second peak of activity was found in relation to the lower yellow spot; with globulin it was in the upper yellow spot. With the homologous serum, inorganic iodide was proportionately greater, but some activity coincided with the lower yellow spot also. In one animal, activity was associated with a conspicuous purple spot (R_F 0·85), which was probably diiodotyrosine; in the remainder this compound appeared to be absent. This latter finding concurs with that of Leblond and Suš[5], though it is at variance with that of Foster and Gutman, all of whom worked with free diiodotyrosine. It also differs from the findings of Knox and Endicott (see ref. 1, addendum to paper), who studied the fate of foreign labelled-proteins in rabbits. They reported that diiodotyrosine and iodide formed the chief excretion products.

It was thought that the compounds responsible for the yellow spots were polypeptides, and confirmation was obtained by hydrolysis. Both the whole urine and also the eluate from the 'yellow spot' area of undeveloped chromatograms were hydrolysed in 6*N* hydrochloric acid. In each case the hydrolysate was resubmitted to chromatography in phenol and developed with ninhydrin. Six separated purple spots representing amino-acids were found, and some of the radioactivity was now associated with diiodotyrosine. Some, however, was still found in a mixed yellow–purple spot (R_F 0·45–0·50), which area was accordingly eluted from an undeveloped chromatogram. When run in an *n*.butanol – acetic mixture, this was resolved into a further five non-radioactive purple spots (R_F ranging from 0·2 to 0·45) and an active yellow one above this. Further elution and hydrolysis followed by chromatography in phenol revealed more amino-acid spots, which again included radioactive diiodotyrosine.

It would appear, therefore, that in the animal the injected proteins are subjected to hydrolysis, which results in the breakdown of part of the molecule and release of inorganic iodide, but also in the release of some stable peptides that still contain iodine in organic combination. The peptide and such of the iodide as is not stored in the thyroid are then excreted in the urine. It also appears that the excreted peptide may differ according to the protein used, although further investigation with other proteins is required to test this point. Examination of the excretion products of labelled proteins appears to offer possibilities to workers in a wider field than that of immunology.

I would like to express thanks to Mr. R. W. R. Baker for valuable assistance in preparing and interpreting the chromatograms.

J. O. Laws

Department of Pathology,
Guy's Hospital Medical School,
London, S.E.1.
Jan. 23.

[1] Wormall, A., *Brit. Med. Bull.*, **5**, 333 (1948).
[2] Elsen, H. N., and Keston, A. S., *J. Immunol.*, **63**, 71 (1949).
[3] Knox, W. C., and Endicott, F. C., *J. Immunol.*, **65**, 523 (1950).
[4] Crampton, C. F., and Haurowitz, F., *Science*, **112**, 300 (1950).
[5] Leblond and Suš, P., *Amer. J. Physiol.*, **134**, 549 (1941).

Histochemical Observations on Genital Cancer

The histochemical test of McManus[1] and Hotchkiss[2] demonstrating the presence of mucopolysaccharides, mucoproteins and glycoproteins was carried out on cancerous tissue of the vagina, portio and corpus uteri, the Fallopian tube and the ovary. The polygonal stratum of the normal epithelium of the portio gives an intense positive test, while the normal stratum basale remains uncoloured. Cancerous tissue fails to give a positive test even in the pre-invasive intra-epithelial stage. The same result was obtained in cancers originating from other parts of the genital tract. Thus our observations indicate that the McManus–Hotchkiss test is a valuable tool in the early diagnosis of cancers in the pre-invasive stage.

In view of the report of Shetlar *et al.*[3,4] that in cases of malignant tumours the protein-bound polysaccharide content of serum albumin is increased, it is of interest that compounds of this nature seem to be absent in the cancer cells. This may indicate that protein-bound carbohydrates may be concerned in some way with malignancy.

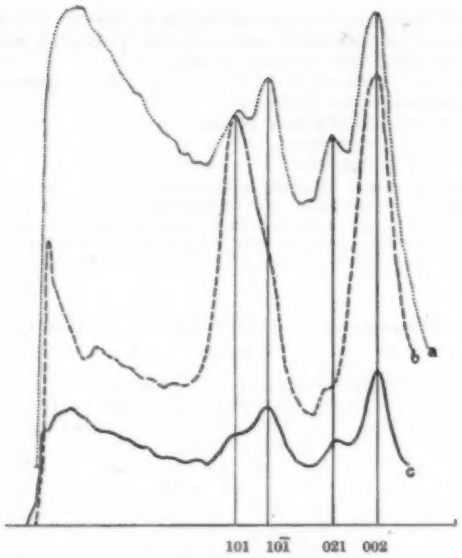
L. Lajos
K. Páli

Obstetrical and Gynæcological Clinic,
University, Pécs. Dec. 10.

[1] McManus, J. F. A., *Nature*, **158**, 202 (1946).
[2] Hotchkiss, R. D., *Arch. Biochem.*, **16**, 131 (1948).
[3] Shetlar, M. R., Foster, Janeal Villett, Kelly, Keith H., Shetlar, C. L., Bryan, R. S., and Everett, Mark R., *Cancer Res.*, **9**, 515 (1949).
[4] Shetlar, M. R., Erwin, Chesley P., and Everett, Mark R., *Cancer Res.*, **10**, 445 (1950).

Micellar Structure of Native Cellulose

Ranby and Ribi[1] have recently described how native cellulose particles of micellar dimensions can be produced by boiling cotton fibres in dilute sulphuric acid and then washing to a *p*H of approximately 4. We have examined the effect on cotton and ramie of more concentrated acid at lower temperatures (for example, 975 gm./l. and 20° C.) and have obtained somewhat similar results. We find that with increasing severity of our treatment the ultimate product of the dissolution appears to consist of particles between 500 and 2500 A. in length with a roughly constant cross-section (50 A. thick and 150–200 A. wide). In the earlier stages of disintegration larger flat aggregates are obtained, and we have been able to prepare brittle transparent films from the colloidal solution of these. X-ray examination of such films shows that, when the X-ray beam is perpendicular to the film, the 101 and $10\bar{1}$ reflexions of cellulose I appear as rings, as they



Photometer records of X-ray photographs of films of cellulose particles. (*a*) X-ray beam perpendicular; (*b*) beam parallel, equator; (*c*) beam parallel, meridian. The intensity scale for (*a*) is different from that for (*b*) and (*c*)

should; but the former is abnormally weak in intensity. When the beam is parallel to the film, a strong 101 reflexion appears on the equator, and 10$\bar{1}$, partly oriented on the equator and partly on the meridian, is weak in comparison. Photometer records showing these results are given in the accompanying diagram. The 101 planes are thus preferentially oriented parallel to the plane of the film. Since the aggregated particles are themselves flat and must thus tend to lie down parallel to the same plane, we deduce that the crystal axial orientation tends to persist throughout the aggregates.

We have not yet been successful in preparing a specimen in which only the ultimate particles appear; but we have observed similar orientation effects in films made from solutions in which the majority of the particles exist as units or very small aggregates. This suggests that the ultimate particles are themselves thinnest in the direction normal to the 101 crystallographic planes, a suggestion which is supported by a careful examination of electron micrographs of disintegrating aggregates, in which the width of the ultimates appears to lie in the plane of the flat sheets. Whether the occurrence of crystallographic orientation in the aggregates is a consequence of the shape of the ultimates, or is rather due to the different activities of the 101 and 10$\bar{1}$ surfaces, cannot as yet be decided; but a more detailed study of some slight differences between the orientation effects in cotton and ramie may throw some light on this question.

It is also noteworthy that, in our X-ray photographs of the less drastically treated material, there appears a strong equatorial small-angle scattering and an equatorial streak (cf. diagram, *b* and *c*). The former in particular is considerably weaker in the corresponding photographs of more completely disintegrated material, and may thus be associated with the details of the building up of the aggregates from the ultimate particles. Both it and the streak are clearly due to some effect in the direction of the normals to the 101 planes.

It is also interesting to note that our attempts to obtain the native cellulose particles from raw jute have been unsuccessful, since the cellulose passes over into the cellulose II modification before the fibres disintegrate*. This suggests that in jute some of the lignin may be present as an intermicellar cement, as we have reason to infer from evidence obtained in other investigations on this fibre[2,3].

* *Note added in proof.* In more recent experiments we have been able to obtain a very small quantity of native cellulose particles from jute when the conditions of treatment were very carefully controlled. Even in the most favourable circumstances, the yield of particles from jute is very much less than from ramie or cotton.

S. M. Mukherjee
J. Sikorski
H. J. Woods

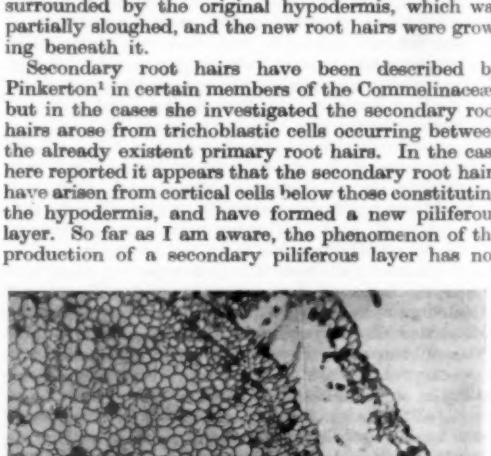
Textile Physics Laboratory,
Department of Textile Industries,
University of Leeds.
Jan. 4.

[1] Ranby and Ribi, *Experientia*, **6**, 12 (1950). Ranby, *Acta Chemica Scand.*, **3**, 649 (1949).
[2] Sen and Woods, *Biochim. et Biophys. Acta*, **3**, 510 (1949).
[3] Mukherjee, R. R., and Woods, *Nature*, **165**, 818 (1950).

A Secondary Piliferous Layer on the Roots of *Hippeastrum*

During the examination of a *Hippeastrum* plant the roots of which were badly attacked by a new species of the nematode genus, *Rotylenchus*, to be described elsewhere, it was noticed that some of the undamaged parts of the roots were covered with root hairs right up to the base of the bulb. Closer examination showed that the root hairs were of secondary origin, for in some cases the root was still surrounded by the original hypodermis, which was partially sloughed, and the new root hairs were growing beneath it.

Secondary root hairs have been described by Pinkerton[1] in certain members of the Commelinaceæ; but in the cases she investigated the secondary root hairs arose from trichoblastic cells occurring between the already existent primary root hairs. In the case here reported it appears that the secondary root hairs have arisen from cortical cells below those constituting the hypodermis, and have formed a new piliferous layer. So far as I am aware, the phenomenon of the production of a secondary piliferous layer has not



been reported before; certainly Cormack[2] makes no mention of it. Outside the new piliferous layer, the hypodermis, of which the old piliferous layer appears to have died, has been sloughed. This hypodermis is usually two cells in depth but in some places is as much as five cells deep. The cells and root hairs of the secondary piliferous layer appear to be no different from those of the primary layer.

The cells of the root cortex seem to be able to become meristematic with ease, and the new piliferous layer is formed from a meristem of this origin. Another manifestation of the same meristematic activity is seen when the root is damaged by eelworm attack. The lesion formed tends to be isolated by a series of cells which have divided tangentially on the inner side of the lesion. A similar phenomenon was described by Quanjer[3] from potato tubers attacked by the eelworm *Ditylenchus dipsaci*, where a cork cambium was produced, isolating the lesion.

J. B. Goodey

Rothamsted Experimental Station,
Harpenden, Herts.
Jan. 16.

[1] Pinkerton, M. E., *Bot. Gaz.*, **98**, 147 (1936).
[2] Cormack, R. G. H., *Bot. Rev.*, **15**, 583 (1949).
[3] Quanjer, H. M., *Tijdschr. PlZiekt.*, **33**, 137 (1927).

Anatomical Factors of Body-Heat Regulation

As has already been shown, the body-weight/body-surface ratio decreases more or less regularly from north to south, and the lowest averages are found in hot climates[1,2]. Manifestly the decrease of the weight/surface ratio in human beings is an anthropological—and strictly biometrical—equivalent of the two well-known zoological 'laws': Bergmann's rule (body-size of related homeotherms decreases in the warmer parts of their geographical range), and Allen's rule (relative increase of protruding organs in warmer districts). I think that a biometrically correct rule may be generalized in the following way: in closely related homeotherms, the body-mass/body-surface ratio tends to decrease in climates which, at least during a part of the year, put a stress on heat-eliminating mechanisms.

Now, the weight/surface ratio is correlated with many anthropometrical indices, suggesting that there are anatomical factors of heat regulation. The following experimental results show that thermal behaviour varies according to body-build, a correlative of weight/surface ratio.

In the first experiment, mature adult men were exposed for about one hour to a dry-bulb temperature of approximately 36° C. Thereafter they were divided into two groups: (1) subjects reacting by strong perspiration (sweat dripping down profusely at least on a part of the body: forehead, chest or axillæ); (2) subjects reacting by a moderate perspiration (shiny skin, but not perceptible drops). I did not take into account subjects difficult to put in one of these well-defined groups. As neglected subjects represent probably the 'average' cases, perspiration appears in these results as a dichotomized variate, excluding the hypothesis of a normal distribution. Therefore, in order to calculate correlations, the point-biserial r formula was employed. The coefficients of correlation between the intensity of perspiration and some anatomical indices are given in Table 1 (number of subjects: 43):

Table 1

Trunk volume/total limb length (Viola)	0·461
Lower limb/trunk height	0·443
Weight/height (Quetelet)	0·342
Upper limb/lower limb	0·252
Abdominal volume/thoracic volume (Viola)	0·224
Thoracic depth/length of sternum	0·202
Body-weight/body-surface ratio	0·336

These figures show that profuse perspiration tends to be associated with the eurysomatic morphological trend: relative preponderance of trunk volume over limb length, of trunk height over lower limb, of upper limb over lower, of abdomen volume over chest volume, of chest depth over sternal length, of body mass over body surface. Of course, moderate perspiration tends to combine with the opposite leptosomatic trend.

These results may seem a little paradoxical. It is stated in text-books that perspiration is the chief method of heat elimination. But perspiration increases with weight/surface ratio and the latter decreases as we go south. Nevertheless the paradox disappears if we remember that the "chief method of heat elimination" is the least economical and the most disturbing. On the average, brachysomorphic individuals perspire too quickly and too profusely: sweat is largely lost without being evaporated. It is a kind of physiological 'hypertely', which can be compared with the mammoth's tusks usually quoted.

The second experiment threw some light on this aspect of the problem. A group of young adult men was submitted for half an hour to a dry-bulb temperature of 36° C. Their mouth temperatures were carefully taken before entering the hot room, then again at regular intervals. Leaving aside the intermediate cases, we can distinguish two groups: (1) ten subjects whose temperature rose to a maximum at the tenth minute; (2) eleven subjects whose temperature rose to a maximum at the thirtieth minute. The characteristics of both groups are given in Table 2:

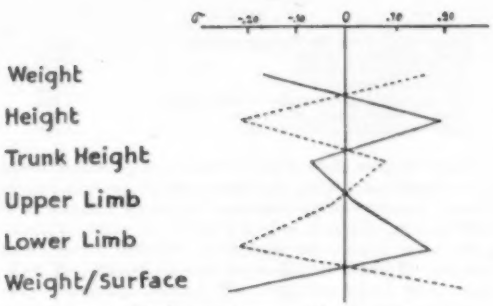
Table 2

	10-min. group	30-min. group
Maximum temperature (° C.)	36·9	36·8
Heat gained in order to reach max. temperature (Cal.) per minute	1·7	0·7
per minute and kgm. of body-weight	0·025	0·011
Weight/surface ratio (kgm./m.²)	37·7	36·7

The maximum temperature reached by the 30-min. group was still lower than the maximum attained by the 10-min. group. The latter accumulated more heat (the heat gain was calculated by taking 0·83 as average thermal capacity of living tissues).

Six subjects of the 30-min. group were observed for 40 min. In one case the temperature rose a little during the additional 10-min. period; in a second case it remained at the 30-min. level; in four cases there was a temperature fall obviously related with intensified perspiration. Therefore, the 30-min. group, with a lower weight/surface ratio, gains heat at a slower rate and its 'last resource' sweat reaction is delayed and relatively weak. On the whole, thermal reactions of the 30-min. group are more economical and more efficient.

Now the anthropometrical profiles of the two groups show perfect anatomical antagonism. In the accompanying graph, averages of each group are compared with averages of the whole sample and



----, 10-min. group; ——, 30-min. group

their deviations from the latter are expressed in standard deviations. Thus, all characters are comparable and we can determine relative anatomical preponderances. For the 10-min. group we find a relative preponderance of weight over height, of trunk height over pelvic limb length, of upper limb over lower limb; the 30-min. group shows the opposite relative preponderances. On the average, the first group is manifestly eurysomatic, the second is leptosomatic. This 'bipolar deformation' coincides with other anatomical gradients revealed by the study of anthropometrical changes as functions of blood pressure and muscular strength, the latter being taken as independent variables[3].

Eugène Schreider

Laboratoire d'Anthropologie Physique,
1 rue René Panhard, Paris XIII.

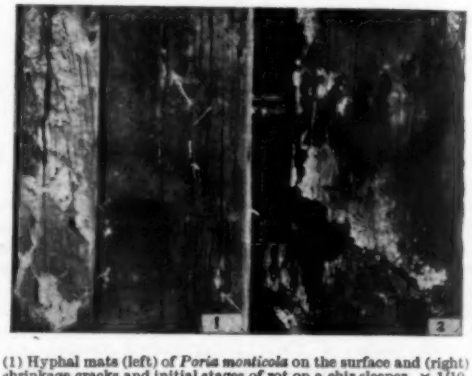
Dec. 29.

[1] Schreider, E., *Nature*, **165**, 286 (1950).
[2] Schreider, E., *L'Anthropologie*, **54**, 67, 228 (1950).
[3] Schreider, E., *Biotypologie*, **10-11**, 53 (1949-50).

Poria monticola Murr. on Chir (*Pinus longifolia* Roxb.) in India

Poria monticola Murr. (= *Poria microspora* Overh.) has so far been known to occur naturally in North America (Canada and United States), where the fungus commonly causes heart rot of living trees (sitka spruce and Douglas fir) as well as decay of coniferous wood in service. The fungus is not known to occur naturally in Great Britain, and is only present in timber imported into the country from North America. During the Second World War, Messrs. Tata Aircraft, Ltd., Bombay, obtained from Canada a supply of 36,000 cu. ft. of sitka spruce for manufacturing aeroplane parts in India. A large number of the planks showed an infection in the form of brown streaks of rot running along the length of the grain. Isolations from the diseased wood yielded a fungus which resembled *Poria monticola* described in culture by Nobles[1] and others. The pockets were superficial and therefore the rot was removed by planing off the surface, and any incipient decay that might have gone inside the wood was arrested by kiln seasoning. The growth of the fungus is also known to be checked if the moisture content of the wood remains less than 20 per cent, based on the oven-dry weight of the wood.

Chir (*Pinus longifolia*) is an important timber species in the central and west Himalayas. The logs are converted in the felling coupes and are floated, along with other timber species, down the rivers into the plains. All these are collected at Dakpathar, Dehra Dun, which is situated at the foot-hills of the Himalayas on the banks of the River Jumna, which comes into the plains at this region. One of us (K. B.), during numerous inspections of timber at Dakpathar, collected chir sleepers, which were frequently affected by a brown rot. Isolations from the rotted wood yielded *P. monticola* in culture. It therefore appears that the fungus is present in a natural condition in India, and that it can be traced into the felling coupes of chir plantations in the Himalayas. Recently, a large consignment of chir sleepers was obtained by the Public Works Department, Government of India. The sleepers were stored in a godown adjacent to the Forest Research Institute, Dehra Dun. The conditions of storage were very unsatisfactory, with poor ventilation. The humidity of the air at Dehra Dun is high during July to September, when there is an average rainfall of 80 in. and the average temperature of the place in summer months is about 95° F. As a consequence, a dry-rot fungus affected and spread rapidly into all the sleepers by the end of September 1949. Thick hyphal mats developed on the surface



(1) Hyphal mats (left) of *Poria monticola* on the surface and (right) shrinkage cracks and initial stages of rot on a chir sleeper. × 1/10.
(2) Fruit bodies of *Poria monticola* on a chir sleeper. × 2/5

(Fig. 1), and occasionally fruit bodies were formed (Fig. 2) which corresponded with *P. monticola* described by Murrill[2]. The rot was of the brown carbonizing type. Isolations from the rot yielded *P. monticola* in culture. Advice was given to reject the sleepers where the rot penetrated into the core, while those with superficial rot and incipient stages of decay were given a sterilizing treatment in steam under pressure and restacked in the open under cover to allow free circulation of air around them. All such sleepers have been found to be healthy up to this date. The fungus caused a severe brown rot on chir sapwood blocks in culture flasks, and the average loss in weight of the blocks was found to be 63 per cent in four months.

Dr. W. P. K. Findlay, to whom the isolate from chir was sent, stated that the fungus is probably *Poria monticola*, to which view we agree from a study of its cultural characters. A detailed account of the fungus will appear elsewhere in a study by us of the fungus diseases and decays of conifers in India.

K. Bagchee
B. K. Bakshi

Mycology Branch,
Forest Research Institute and Colleges,
Dehra Dun, India. Dec. 20.

[1] Nobles, M. K., *Canad. J. Res.*, **C26**, 389 (1948).
[2] Murrill, W. A., *Mycologia*, **12**, 90 (1920).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 21

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. K. R. Popper: "A Critical Discussion of Operationalism and related Views".

Tuesday, May 22

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. Denis McMahon: "Practical Training for Psychology Students—the Work of a University Psychology Unit".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (at the Institute of Physics, 47 Belgrave Square, London, S.W.1), at 4 p.m.—Radiochemistry Meeting.

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. Paul Bohannan: "Divination among the Tiv of Central Nigeria".

ROYAL SOCIETY (at the Institute of Marine Engineers, 85 Minories, London, E.C.3), at 5.30 p.m.—Prof. L. C. Burrill: "Sir Charles Parsons and Cavitation" (Parsons Memorial Lecture).

BRITISH ORNITHOLOGISTS' UNION (joint meeting with the SYSTEMATICS ASSOCIATION, at the Zoological Society of London, Regent's Park, London, N.W.8), at 6 p.m.—Dr. Ernst Mayr: "Birds and the Origin of Species".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Biological and Chemical Control of Insect Pests" (Speakers: Dr. V. B. Wigglesworth, F.R.S., Dr. R. A. E. Galley, Mr. G. V. B. Herford and Dr. G. S. Hartley).

Wednesday, May 23

ROYAL SOCIETY OF MEDICINE, ENDOCRINOLOGY SECTION (joint meeting with the SOCIETY FOR ENDOCRINOLOGY, at 1 Wimpole Street, London, W.1), at 2 p.m.—Symposium on "A.C.T.H.".

CHEMICAL COUNCIL (at the Royal Institution, Albemarle Street, London, W.1), at 3 p.m.—Sir Jack Drummond, F.R.S.: "Chemistry and the Food We Eat" (Chemistry in the Service of Man, 2).

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Sir Edward MacColl: "Hydro-Electric Power Development in Scotland".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. M. S. C. Birbeck: "Histological Techniques for the Electron Microscope".

UNITED NATIONS FELLOWSHIP (in the Ceylon Room, Royal Empire Society, Northumberland Avenue, London, W.C.2), at 8 p.m.—Discussion on "Bi-National Cultural Activities".*

BRITISH PSYCHOLOGICAL SOCIETY, MEDICAL SECTION (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 8.30 p.m.—Dr. W. S. Inman: "The Moon, the Seasons and Man".

INSTITUTE OF METALS (at 4 Grosvenor Gardens, London, S.W.1)—Sir John Anderson, F.R.S.: Annual May Lecture.

Thursday, May 24

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Dr. D. J. Bell: "Biological Syntheses concerning Carbohydrate Radicals".* (Further Lectures on May 31, June 7 and 14.)

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. J. L. Thompson: "The Resistance Wire Strain Gauge in the Measurement of Physical Quantities".

Friday, May 25

PHYSICAL SOCIETY (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Sir George Simpson, F.R.S.: "Fifty Years' Work in Geomagnetism and Geophysics—Some Reminiscences" (6th Charles Chree Address).

INSTITUTION OF ELECTRONICS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 7 p.m.—Mr. L. Atkinson: "High Voltage Oscillograph for Photography of Transients".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN THE DEPARTMENT OF ENGINEERING, Wednesbury County Technical College—The Director of Education, Department F.E., County Education Offices, Stafford (May 26).

MECHANICAL ENGINEER in the Heavy Research Plant Section of the Chief M. and E. Engineer's Division, Ministry of Works—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.259/51A (May 26).

SCIENTIFIC OFFICERS (2) (with at least second-class honours degree with mathematics or physics as main subject, or an engineering degree with a very strong mathematical background) to deal with mathematical problems arising from research into civil defence fundamentals—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.148/51A (May 26).

PRINCIPAL MEDICAL OFFICER (Research) at a Ministry of Supply establishment in south-west England, to organize and superintend investigations into the physiological, pathological, pharmacological and biochemical effects of toxic materials—The Appointments Officer, Ministry of Labour and National Service, 1–6 Tavistock Square, London, W.C.1, quoting J.O.35 (May 28).

AGRICULTURAL ECONOMIST and ASSISTANT AGRICULTURAL ECONOMISTS, grade (*a*) or (*b*), in the Department of Agricultural Economics—The Registrars, The University, Manchester 13 (May 31).

ASSISTANT LECTURER IN MATHEMATICS—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4 (May 31).

COATS FELLOWSHIP IN CHEMISTRY or PHYSICS (excluding nuclear physics)—The Clerk of Senate, The University, Glasgow, W.2 (May 31).

ENGINEER I at a Ministry of Supply establishment in south-east England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.205/51A (May 31).

ENGINEER I in the Ministry of Supply Directorate of Ordnance Factories/Engineering, London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.204/51A (May 31).

PRINCIPAL LECTURER or SENIOR LECTURER IN HEAT ENGINES, a SENIOR LECTURER IN MACHINES, LECTURERS (2) IN MACHINES, a SENIOR LECTURER IN PHYSICS, a SENIOR LECTURER IN ELECTRICAL ENGINEERING, a LECTURER IN ELECTRICAL ENGINEERING, a SENIOR LECTURER IN STRUCTURAL DESIGN, and DEMONSTRATORS (13) IN MATHEMATICS, PHYSICS, CHEMISTRY and ENGINEERING, at the Military College of Science, Shrivenham, Swindon—The Civil Service Commission, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4026/51 (May 31).

SENIOR BACTERIOLOGIST and/or MICROBIOLOGIST, to engage in fundamental research in brewing microbiology and allied fields—The Director, Brewing Industry Research Foundation, Nutfield, Surrey (May 31).

SENIOR LECTURERS and LECTURERS IN SCIENCE AND ENGINEERING, a SENIOR LECTURER IN MATHEMATICS, and a LECTURER IN MODERN SUBJECTS, at the Royal Military Academy, Sandhurst—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4027/51 (May 31).

JUNIOR FELLOWSHIP IN APPLIED MATHEMATICS—The Registrar, The University, Bristol (June 1).

PHYSICAL CHEMIST (with a good degree with a strong bias towards physical chemistry) to act as team leader and to take charge of the laboratory under general direction from the B.E.A. headquarters' organization, a PHYSICAL CHEMIST (with a good honours degree or expecting to obtain one shortly, thoroughly interested in the theory and the experimental techniques that are associated with corrosion research, and a capable experimenter), and an EXPERIMENTAL OFFICER to help with the experimental work (should have a good knowledge of chemistry and, preferably, have had experience of boiler operation or of the preparation and photomicrography of metallurgical specimens), in the Research Branch of the Chief Engineer's Department in London—The Secretary's Office (Establishments), Applications Section, British Electricity House, Great Portland Street, London, W.1, quoting Ref. AE/150 (June 1).

DEMONSTRATOR (with a good honours degree in physiology, biochemistry or chemistry with subsidiary physiology) IN CHEMICAL PATHOLOGY—The Registrars, The University, Manchester 13 (June 9).

RESEARCH OFFICERS (4) IN THE SECTION OF CHEMICAL ENGINEERING, Division of Industrial Chemistry, Fishermen's Bend, Melbourne, for work associated with the Division's recently established fuels utilization research programme—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3387 (June 9).

LECTURER IN ASTRONOMY—The Secretary, The University, Aberdeen (June 15).

LECTURER (with a Special Degree in botany or its equivalent) IN THE DEPARTMENT OF BOTANY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (June 15).

PHYSICAL CHEMIST (Scientist, Grade I) to take charge of investigations related to the improvement and discovery of processes for resolving complex mixtures of solids into their components (Ref. TT/327), a COAL PREPARATION OR MINERALS ENGINEER (Scientist, Grade I) to take charge of laboratory, pilot plant and field investigations for the development of wet processes for cleaning coal (Ref. TT/328), a PHYSICAL CHEMIST (Scientist, Grade II) for laboratory investigations of the underlying principles and mechanism of coal cleaning processes (Ref. TT/329), a COAL PREPARATION OR MINERALS ENGINEER (Scientist, Grade II) for pilot plant investigations into coal cleaning by wet processes (Ref. TT/330), a PHYSICAL CHEMIST (Scientist, Grade III) with not less than 2 years postgraduate experience in industry, preferably in the quantitative aspects of distillation and catalytic work on either laboratory or pilot plant scale (Ref. TT/331), a PHYSICAL CHEMIST (Scientist, Grade III) with experience in X-ray analysis (Ref. TT/332), a CHEMIST or CHEMICAL ENGINEER (Scientist, Grade III) for laboratory research on coal breaking, grinding and briquetting (Ref. TT/333), and CHEMICAL ENGINEERS (Scientist, Grade III) to design and operate laboratory and pilot plant equipment with particular reference to distillation and catalytic processes (Ref. TT/334)—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting the appropriate Ref. No. (June 29, except Ref. TT/328, August 31).

AERONAUTICAL AND MECHANICAL ENGINEERS (Experimental Officer grade) at Ministry of Supply research and development establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.679/50A.

ASSISTANT BIOCHEMIST—The Secretary, Royal Infirmary, Bolton.

ASSISTANT EXPERIMENTAL OFFICERS (2) for recording, plotting and analysis of locust movements and preparation of maps—The Director, Anti-Locust Research Centre, British Museum (Natural History), South Kensington, London, S.W.7.

DAIRY AND POULTRY OFFICER in the Veterinary Department, Northern Rhodesia—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27066/47.

ELECTRICAL ENGINEER (Meters and Protection) by the Central Electricity Board, Federation of Malaya—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.25727.B.

ENGINEER-GEOLOGISTS in the Public Works Department, Kenya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27079/18/51.

FORECASTER by the Falkland Islands Dependencies Survey, for service in South Georgia and Port Stanley—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.27292.E.

HEAD OF THE COLLEGE—The Clerk, National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

LECTURER IN PHYSICAL CHEMISTRY—The Registrar, College of Technology, Union Street, Bristol 1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Hungary Builds a New Education. By Max Morris. (Hungary Today Series, 4.) Pp. 16+16 plates. (London: Hungarian News and Information Service, 1950.) 6*d*. [132

Forty-third Annual Report of the Governing Body of the Imperial College of Science and Technology. Pp. 51. (London: Imperial College of Science and Technology, 1951.) [132

Anti-Locust Bulletin 6: Reproduction in the African Migratory Locust (*Locusta migratoria migratorioides* R. and F.) in relation to Density and Phase. By Dr. Maud J. Norris (Mrs. O. W. Richards.) Pp. ii+50. (London: Anti-Locust Research Centre, c/o British Museum (Natural History), 1950.) [132

Joint Consultation: a Practical Approach. Pp. 48. (London: Institute of Personnel Management, 1950.) 2*s*. 6*d*. [132

Department of Scientific and Industrial Research: Building Research Station. National Building Studies, Technical Paper No. 6: Investigations on Building Fires, Part 4, Fire Resistance of Timber Doors. By C. J. Webster and L. A. Ashton. Pp. iv+20+3 plates. (London: H.M. Stationery Office, 1951.) 1*s*. net. [142

Forestry Commission. Booklet No. 3: Chestnut Blight caused by the Fungus *Endothia parasitica*. Pp. 4+4 plates. 2*s*. 6*d*. Britain's Forests—Tintern. Pp. 16. 9*d*. net. Britain's Forests—Coed y Brenin. Pp. 16. 9*d*. net. (London: H.M. Stationery Office, 1950.) [142

Furniture Development Council. Technical Bulletin, Vol. 1, No. 1, January–February. Pp. 20. (London: Furniture Development Council, 1951.) 6 issues, 15*s*. [142

Department of Scientific and Industrial Research. Report of the Geological Survey Board for the Year 1949. Pp. ii+18. (London: H.M. Stationery Office, 1950.) 9*d*. net. [142

Proceedings of the Society for the Study of Fertility. No. 1: Edinburgh Conference, 1949. Pp. iii+44. (Cambridge: W. Heffer and Sons, Ltd., 1950.) 10*s*. [142

Colonial Products Advisory Bureau (Plant and Animal): Consultative Committee on Insecticide Materials of Vegetable Origin. Report of the Standing Sub-Committee on Methods of Analysis of Vegetable Insecticides on the World-Wide Collaborative Analysis of Pyrethrum Flowers, 1948–1949. Pp. iv+64. (London: Colonial Products Advisory Bureau, 1950.) 4*s*. [73

Kirkstall Abbey Excavation. First Report, 1950. By T. A. Hume and Dr. D. E. Owen. Pp. 12+2 plates. (Leeds: Thoresby Society, 1951.) 1*s*. [73

Department of Scientific and Industrial Research: Radio Research. Special Report No. 20: Valve and Circuit Noise; a Survey of Existing Knowledge and Outstanding Problems. Pp. iv+19. (London: H.M. Stationery Office, 1951.) 9*d*. net. [73

University of Cambridge: School of Agriculture. Memoir No. 22: A Summary of the Papers published by the Members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1949–Sept. 30th, 1950. Review Series No. 5: A Survey of the Horticultural Research Station, 1922–1949. Pp. 24. (Cambridge: School of Agriculture, 1951.) 2*s*. 6*d*. [73

Commonwealth Economic Committee. Industrial Fibres: a Summary of Figures of Production, Trade and Consumption relating to Cotton, Wool, Silk, Flax, Jute, Hemp, Mohair, Coir and Rayon. Pp. xiv+149. (London: H.M. Stationery Office, 1951.) 5*s*. net. [73

Other Countries

Pubblicazioni dell'Università Cattolica del Sacro Cuore. Nuova Serie, Vol. 35: Contributi del Laboratorio di Psicologia, Serie quattordicesima. Pp. viii+387. (Milano: Società Editrice 'Vita e Pensiero', 1950.) 2,500 lire. [181

United Nations: Department of Social Affairs. Bulletin No. 4: Housing and Town and Country Planning. Pp. iii+121. (New York: United Nations; London: H.M. Stationery Office, 1950.) 1.50 dollars; 11*s*. [181

Health Progress in the United States: a Survey of Recent Trends in Longevity. By Mortimer Spiegelman. (National Economic Problems, No. 439). Pp. 28. (New York: American Enterprise Association, Inc., 1950.) 50 cents. [181

Publications of the Dominion Observatory, Ottawa. Vol. 14: Bibliography of Seismology, No. 7, Items 7222–7417, January to June 1950. By W. G. Milne. Pp. 145–164. (Ottawa: King's Printer, 1950.) 25 cents. [181

The Types of Symbiotic Linkage and their Significance for the Formation of Highly Organized Forms, Functions and Life Spheres in the Phylogenetic Process of Development. By Prof. Richard Falck. Pp. ii+18. (Jerusalem: Research Council of Israel, 1950.) 100 prutot. [181

Publications of the Kapteyn Astronomical Laboratory at Groningen. No. 54: The Elements of the Eclipsing Binaries brighter than Photographic Magnitude 8·50 at Maximum. By L. Plaut. Pp. iii+78. (Groningen: Hoitsema Bros., 1950.) [181

United States Department of the Interior: Geological Survey, Bulletin 962-B: Antimony Deposits of El Antimonio District, Sonora, Mexico. By Donald E. White and Reinaldo Guiza. Pp. iv+81–120+plates 13–25. 70 cents. Bulletin 976-B: Geophysical Abstracts 141, April–June 1950, Numbers 11908–12125. By Mary C. Rabbitt and S. T. Vesselowsky. Pp. iii+71–140. 25 cents. Water-Supply Paper 1068: Wells and Water Levels in Principal Ground-Water Basins in Santa Barbara County, California. By G. A. LaRocque, Jr., and others. Pp. v+459+7 plates. n.p. Water-Supply Paper 1072: Water Levels and Artesian Pressure in Observation Wells in the United States in 1946, Part 2, Southeastern States. Pp. vi+272. 75 cents. Water-Supply Paper 1085: Surface Water Supply of the United States, 1947, Part 5, Hudson Bay and Upper Mississippi River Basin. Pp. xii+479. 1 dollar. Water-Supply Paper 1093: Surface Water Supply of the United States, 1947, Part 13, Snake River Basin. Pp. viii+269. 60 cents. Water-Supply Paper 1114: Surface Water Supply of the United States, 1948, Part 4, St. Lawrence River Basin. Pp. viii+296. 65 cents. Water-Supply Paper 1117: Surface Water Supply of the United States, 1948, Part 7, Lower Mississippi River Basin. Pp. ix+418. 1 dollar. Water-Supply Paper 1119: Surface Water Supply of the United States, 1948, Part 9, Colorado River Basin. Pp. ix+421. 1 dollar. Water-Supply Paper 1120: Surface Water Supply of the United States, 1948, Part 10, The Great Basin. Pp. vii+216. 50 cents. Water-Supply Paper 1121: Surface Water Supply of the United States, 1948, Part 11, Pacific Slope Basins in California. Pp. xi+449. 1.25 dollars. (Washington, D.C.: Government Printing Office, 1949–1950.) [122

Unesco. List of Scientific Papers published in Latin America, 1949. Pp. xlvi+506. Scientific Institutions and Scientists in Latin America: Mexico, Vol. 1. Pp. ii+214. (Montevideo: Unesco Centro de Cooperación Científica para América Latina, 1950.) [132

United States Department of Agriculture. Technical Bulletin No. 1016: Vegetable Weevils and their Natural Enemies in Argentina and Uruguay. By Harry L. Parker, Paul A. Berry and Aquiles Silveria. Pp. 28. (Washington, D.C.: Government Printing Office, 1950.) 10 cents. [132

Smithsonian Institution: United States National Museum. Bulletin 199: An Annotated Check List and Key to the Reptiles of Mexico, exclusive of the Snakes. By Hobart M. Smith and Edward H. Taylor. Pp. v+253. (Washington, D.C.: Government Printing Office, 1950.) 75 cents. [132

Kungl. Lantbrukshogskolans Annaler (Annals of the Royal Agricultural College of Sweden). Vol. 17. Pp. vi+484. (Uppsala: Kungl. Lantbrukshogskolan, 1950.) [132

Institut de France: Académie des Sciences. Annuaire pour 1951. Pp. 238. (Paris: Libr. Gauthier-Villars, 1951.) [132

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Administrative Report of the Government Museum, Madras Pudukkottai Museum and the Connemara Public Library, Madras, for 1949–50. Pp. 42. (Madras: Government Printer, 1950.) [132

Indian Forest Records, New Series. Entomology, Vol. 8, No. 3: Larvae of Two Species of Anthribidae. By Dr. R. N. Mathur. Pp. 13–16+1 plate. 5 annas; 6*d*. Entomology, Vol. 8, No. 2: Indian Longicorn Beetles (Coleoptera, Cerambycidae), Part 1. By J. Linsley Gressitt. Pp. 9–12. 4 annas; 5*d*. (Dehra Dun: Forest Research Institute, 1950.) [132

An International Bibliography on Atomic Energy. Vol. 1: Political, Economic and Social Aspects, Supplement No. 1. Pp. v+22. (Lake Success, N.Y.: United Nations; London: H.M. Stationery Office, 1950.) 1*s*. 9*d*. [132

Kgl. Danske Videnskabernes Selskab. Biologiske Meddelelser, Bind 18, Nr. 12: Phytoplankton Studies, 1, *Nitzschia frigida* Grun., an Arctic-Inner-Baltic Diatom found in Danish Waters. By Jul. Grøntved. Pp. 20+1 plate. (København: Einar Munksgaard, 1950.) 12 D. cr. [132

Union of South Africa; Department of Education, Arts and Science. Report of the Archaeological Survey of the Union of South Africa for the Period 1st April 1949 to 31st March 1950. (Annual Report No. 15.) Pp. iii+8. (Pretoria: Government Printer, 1950.) [132

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Canada: Department of Mines and Technical Surveys. Geological Survey of Canada, Memoir 256: Pleistocene Geology of the Lake Simcoe District, Ontario. By R. E. Deane. (No. 2494.) Pp. vii+108+14 plates. (Ottawa: King's Printer, 1950). 1 dollar. [132

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Aperiodic Balance. Pp. 8. d'Arsonval Galvanometer with Integral Lighting. Pp. 2. 'Modern' Spectrometer. Pp. 4. Filter Pump. Pp. 2. Optical Bench. Pp. 12. (London and Birmingham: W. and J. George and Becker, Ltd., 1951.)

Mathematik, Physik, Chemie und chemische Technologie, Mineralogie, Geologie, Meteorologie, Astronomie, 1945–1950. Pp. 32. (Wien: Springer-Verlag, 1950.)

Metropolitan-Vickers Gazette. Vol. 23, No. 384, February 1951. Pp. 297–320+xii. (Manchester: Metropolitan-Vickers Electrical Co., Ltd., 1951.)

Mathematics, Statistics, Astronomy, Physics—Antiquarian, New and Forthcoming. (Catalogue 636). Pp. 94. (Cambridge: W. Heffer and Sons, Ltd., 1951.)

Wild-Barfield Vertical Crucible Muffles. (M.1050/V/2m). Pp. 2. (Watford: Wild-Barfield Electric Furnaces, Ltd., 1951.)

TMC Technical Journal. Vol. 2, No. 1, March 1951. Pp. 36. (London: Telephone Manufacturing Co., Ltd., 1951.)

Rohm and Haas Reporter. Vol. 8, No. 5, November–December 1950. Pp. 22. (Philadelphia: Rohm and Haas Company; London: Charles Lennig and Co. (Great Britain), Ltd., 1950.)

Bulletin des Publications nouvelles, 1950. Pp. 40. (Paris: Libr. Gauthier-Villars, 1950.)

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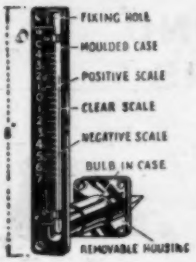

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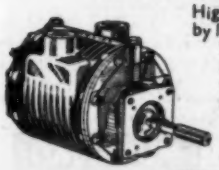

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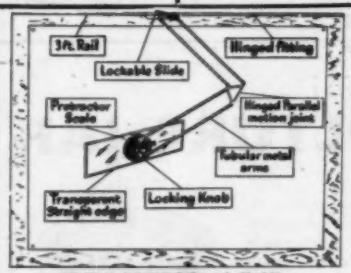

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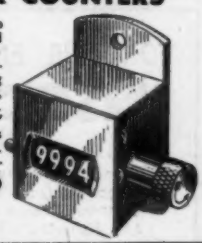

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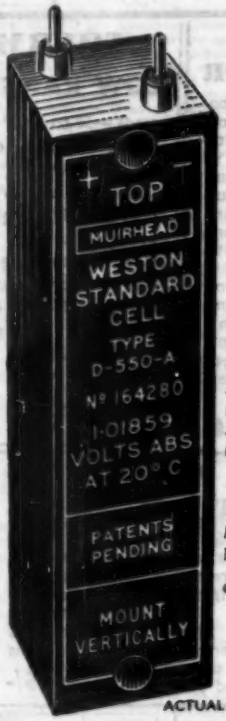

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